DISCOVERY

Monthly Notebook

The Pay of Science Teachers
Gay-Lussac Centenary
The Wandering Eye
Insect Control by Virus
New Source of Sulphur

Flowers and their Perfumes

R. W. MONCRIEFF, B.Sc., F.R.I.C.

Science by Radio

ARCHIE CLOW, M.A., Ph.D., D.Sc.
Producer of the B.B.C.'s 'Science Survey'

Bird Migration

A. J. MARSHALL, B.Sc., D.Phil.

How Bees find their Way

C. G. BUTLER, M.A., Ph.D.

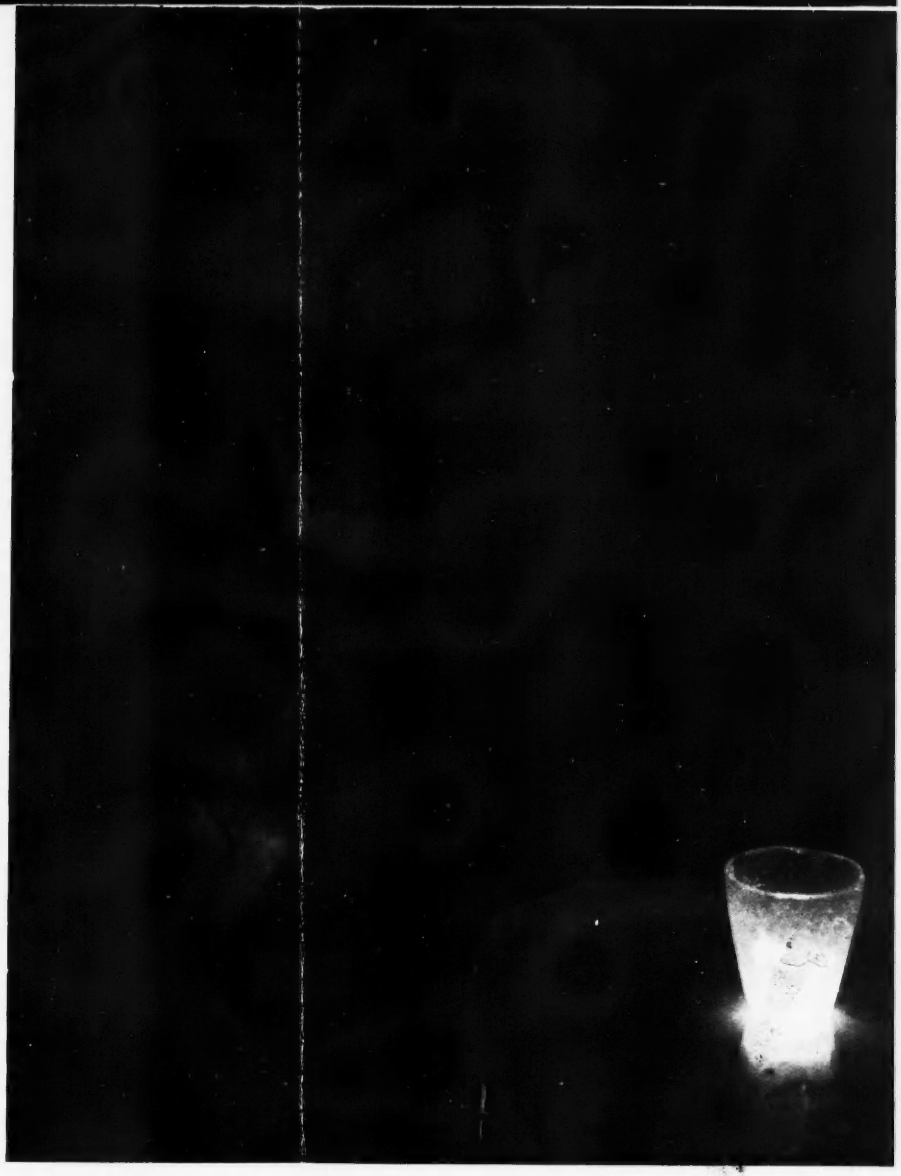
Marine Biology at Naples

JOHN CRAMMER

The Extraction of Radium

Harnessing the Tides

ROLT HAMMOND, A.C.G.I., A.M.I.C.E.



UNIVERSITY OF MICHIGAN
NOV 27 1950
PERIODICAL READING ROOM

NOVEMBER

1950

1/6

SCIENTIFIC EQUIPMENT

Rotary Vacuum Pumps; Phosphorus Pentoxide Vapour Traps; Glow Discharge Vacuum Indicator; Spark Test Set; Magnetically Released Vacuum Valve; Oil Diffusion Pumps, 7 to 3,500 litres per second; High Vacuum Valves, ½" to 20" diameter, manually operated; High Vacuum Valves, ½" to 20", power operated; High Vacuum Pipework; High Vacuum Flanged Joints; Cold Traps—CO_2—liquid air—refrigerated; Pirani Vacuum Gauge; Ionisation Vacuum Gauge; Pirani Vacuum Relays; Complete High Vacuum Pumping Plants; Vacuum Furnaces; High Vacuum Evaporation Plant, for aluminising; High Vacuum Evaporation Plant, for blooming optics; Liquid Flow Relays; Freeze Drying Equipment; Oil Stripper Units for mechanical vacuum pumps; Nuclear Physics Equipment; Cyclotrons; Betatrons; Electron Microscope; Shadow Casting Jig; Vacuum Desiccator for drying plates; Evaporation Plant for shadow casting; Fluorescent Viewing Box; Precision Current Stabilisers Mass Spectrometers; Magnetic Crack Detectors; Electron Diffraction Camera; Creep Testing Equipment; H.V. Laboratory Equipment; Large Electromagnets; Vacuum cold water degassing equipment.

Send your enquiries

METROPOLITAN-VICKERS ELECTRICAL CO. LTD.

TRAFFORD PARK, MANCHESTER 17

Member of the A.E.I. group of companies

C/Z90

CHAPMAN & HALL

THE IDENTIFICATION OF MOLECULAR SPECTRA

by

R. W. B. Pearse D.SC., F.R.A.S. **and** **A. G. Gaydon** D.SC.

Second Edition, Revised

Size: 11" × 7¾" *276 pages* *12 plates* *50s. net*

Since the first edition of these tables was published, many new papers on molecular spectra have appeared in the literature. When preparing the second edition the authors endeavoured to include new data up to 1947; and, since then, have been able to insert in proof stage, references and some new data as late as November 1949. The amount of material included is thereby considerably increased.

BOTANY

AN INTRODUCTION TO PLANT SCIENCE

by **Wilfred W. Robbins and T. Elliot Weier**

(Professors of Botany, College of Agriculture, University of California)

Size: 9¾" × 7½" *480 pages* *Fully illustrated* *40s. net*

This book deals with the basic facts of plant science and how they affect agriculture, medicine, and many other fields. Nearly 500 illustrations help to clarify further some detail in the text. Many of them are actually part of the reading matter, like chemical and mathematical equations in engineering books.

37 ESSEX STREET, LONDON, W.C.2

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

November, 1950 Vol. XI. No. 11

Editor WILLIAM E. DICK, B.Sc., F.L.S.
Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Advertisement Office: Temple Chambers, Temple Avenue, London, E.C.4. Tel. City 6537 (Three Lines)
All Subscriptions, Distribution and Business Communications to Jarrold & Sons Ltd., Norwich. Tel. Norwich 25261

The Progress of Science

Why be a Science Teacher!

THE upper ranks of Government scientists are getting an increase in salary. Those who were in the £950–£1250 a year range will receive £1000–£1375. Scientific careers in the Civil Service are thus made more attractive, and by comparison the inadequacy of the salaries which are paid to science masters is made even more glaring.

The situation in schools and technical colleges is now quite desperate. A newly fledged scientific graduate would have to be filled with a very compelling sense of vocation to choose teaching as his career. The plain truth is that the schools and technical colleges are not attracting the personnel they need. This was made very clear in the recent House of Commons debate (see DISCOVERY, July 1950, pp. 205–206), during which it was stated that things are now so bad that many grammar schools are dropping science from their curricula altogether because it is impossible to get science masters.

Recently the Education Research Committees of the Federation of British Industries held a conference on Industry and the Universities. The proceedings of this conference are now published.* The supply of science teachers for schools was discussed, and during this discussion Sir Wallace Akers made the very emphatic statement that "The number of science graduates offering to go into teaching of natural science is now almost nil." Sir Wallace considered that the only reason for this was the ridiculously low salary of science teachers. The starting salary is £330. Two years elapse before he gets any increment, and then the annual increment is £15 a year, up to a maximum of £600. Then only by getting a headmastership or a position of special responsibility (carrying with it administration duties) could he hope to get more than £600.

The situation is desperate, yet the Ministry of Education does nothing about revising the Burnham Scale, with a view of attracting more scientists into our schools and colleges. Sir Wallace Akers proposed drastic action. He said: "The Ministry of Education should be attacked through the Board of Trade as industry can, legitimately and properly, point out to the Board of Trade that, unless something is done, the supply of scientific recruits for industry will fall off, and when that happens production also will fall off. It should be suggested, therefore, to the President of the Board of Trade that he should urge his colleague, the Minister of Education, to do something to alleviate the position. That something would not be to give science masters higher emoluments than arts masters, but adequate recognition, in the Burnham Scale, of ability as well as age, so that headmasters could grant a higher scale of pay to masters of special ability in science, arts or any other subject."

It should do, for this serious shortage in the supply of science teachers is highlighted in the latest report of its own Advisory Council on Scientific Policy.

Surely the Government now realises the urgency for action. This present Government is always urging the superiority of a planned economy over free enterprise. To maintain the present state of affairs when new science graduates are being attracted away from science teaching is the reverse of good planning. If this trend is allowed to continue, the future for British science and technology will be gloomy indeed. The science master is the king pin; unless science masters are forthcoming in adequate numbers, the supply of scientists needed by industry and by the Government must eventually dry up.

* *Report of the Conference on Industry and the Universities.* F.B.I., 21 Tothill Street, London, S.W.1. Price 3*s*.

Gay-Lussac's Centenary

THE period from 1778 to 1850 spanned by the life of Joseph Gay-Lussac is one of the most important in the history of chemistry. Only four years before his birth, in 1774, Priestley had discovered oxygen and this led Lavoisier to the first clear idea that the calcination of metals, combustion generally, and the respiration of animals were all processes involving combination with oxygen. This marked the end of the phlogiston theory of combustion, which had dominated chemical thought for nearly a century. Lavoisier and his successors stripped from chemistry the old terminology of the phlogistonists and introduced many of the terms which are in common use today. In the last quarter of the eighteenth century Joseph Black of Glasgow completed his

classic experiments on the composition of alkalis and Henry Cavendish determined the composition of water. In 1807 Dalton published his atomic theory which, with some modifications resulting from our present detailed knowledge of the nature of atoms themselves, is still the very keystone of chemistry. By 1840 a clear idea of valency was developed and the reasons why atoms combine in definite proportions was becoming clear. The same year was marked by the foundation of the Chemical Society in London, symbolic of the new unity which chemistry had acquired.

In this chemical revolution Gay-Lussac played a leading role; Davy, his outstanding British contemporary, regarded him as the most able member of the French school of chemistry at that time.

Gay-Lussac's professional career dates from the year 1800, when he left the *École Polytechnique* as one of its most brilliant graduates. From Paris he went to Arcueil, to work in Berthollet's laboratory, where his researches were mainly in the field of what we should now call physical chemistry. He studied particularly the properties of gases and vapours and in order to collect samples of the upper atmosphere for analysis he made a number of balloon ascents, achieving on one occasion a height of more than 21,000 feet.

The years 1805 and 1806 Gay-Lussac spent with von Humboldt in a tour of Italy and Germany. On his return to Paris he was elected a member of the *Institut de France* and in 1809 became professor of practical chemistry in the *École Polytechnique*. These were busy years. In 1808 he read, before a meeting of the very exclusive chemical society founded by Berthollet, a paper formulating his law of gaseous combining volumes. This law, which is of fundamental importance, states that when gases combine chemically the volumes which react have a simple numerical relationship to each other. For example, a volume of nitrogen combines with three volumes of hydrogen to form two volumes of ammonia. This law, taken in conjunction with the hypothesis of Avogadro, according to which equal volumes of gases (under identical conditions) contain equal numbers of molecules, provided chemists with a reliable method of determining atomic and molecular weights, about which considerable doubts then existed.

During these years Gay-Lussac was married. He met his future wife while she was acting as assistant in a draper's shop. To his surprise—which would doubtless have been even greater had the episode occurred today—the girl was occupying her time between serving customers in reading a text-book of chemistry. He arranged for her further education and then, in 1808, having groomed her to his requirements, they were married. This novel experiment, like those in his laboratory, proved most successful. Unhappily, however, the first year of his married life was marred by a serious accident in which his sight was permanently impaired. In some experiments with metallic potassium, isolated for the first time by Davy only a few months before, which he was carrying out with his collaborator Thénard, an explosion occurred and he was seriously injured.

It was with Thénard too that Gay-Lussac carried out his famous controversy with Davy on the composition of hydrochloric acid. Lavoisier had maintained that oxygen was an essential constituent of all acids and for this reason Thénard and Gay-Lussac believed that oxygen must be present in hydrochloric acid; after much dispute, however, Davy was able to show conclusively that this acid, like many others, contains no oxygen at all.

From the chemistry of the alkali metals and the alkaline earth metals, barium and calcium, Gay-Lussac turned his attention to the halogens. In 1809 he had prepared, with Thénard, concentrated hydrofluoric acid. In 1814 he demonstrated that iodine is an element. In 1815 he prepared cyanogen, a substance which, as he showed, has certain strong resemblances to the halogens. He also developed the method of volumetric analysis which today is, with only slight modifications, universally used.

His work then entered rather a different phase, one in which he was concerned less with theory than with practice. Since 1806 he had been a member of a government committee of arts and manufactures. In 1818 he was made superintendent of an explosives works and in 1829 assayer-in-chief at the mint. Finally, in 1832 he resigned from his chair of chemistry to become professor of general chemistry at the Museum of Natural History. In the field of technology he scored many new successes. His name is perpetuated in the chemical industry in the Gay-Lussac Tower, used for the absorption of nitrous fumes in the lead-chamber process for manufacturing sulphuric acid. This important invention is said to have been completely worked out by him in a single day. In researches on the chemistry of wood he developed a process for making wood fire-proof by impregnation with borax, and another for manufacturing oxalic acid from sawdust.

It is said that soon after Gay-Lussac, as a young man of twenty-two, entered Berthollet's laboratory, the latter informed him, "Young man, your destiny is to make discoveries". This destiny was indeed amply fulfilled.

Louis Joseph Gay-Lussac. 1778–1850.

A New Source of Sulphur

SULPHURIC ACID is one of the key chemicals in modern industry, and so dependent are many processes on the availability of sulphuric acid that consumption of that acid provides a reliable index of a country's industrial activity. The manufacture of sulphuric acid is based on sulphur, deposits of which are comparatively rare. Moreover the world supplies are being used up at a great rate, and are likely to be exhausted in a comparatively short time.

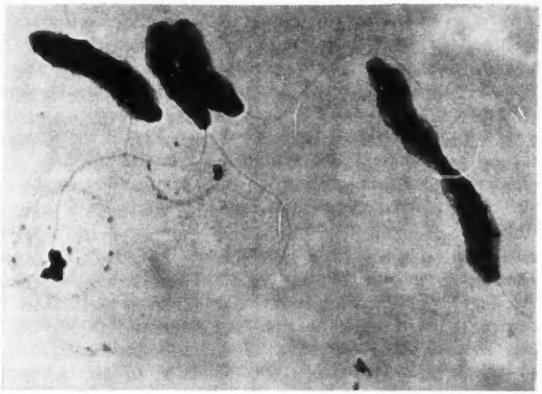
All the sulphur used in Britain has to be imported, and hence the news of some research that is going on at the Chemical Research Laboratory, Teddington, and which offers some promise that an alternative source of sulphur might be made available holds special interest for this country.

The process which might prove capable of augmenting sulphur supplies is a biological one. At the centre of the process are the micro-organisms known as sulphate-reducing bacteria which reduce sulphates to sulphides. In a number of lakes in Africa this process goes on naturally, the final product being a deposit of sulphur at the bottom of the lakes. Two scientists, Mr. K. R. Butlin and Mr. J. Postgate, of the Chemical Research Laboratory have been studying some Libyan lakes from this point of view.

One typical lake they examined was covered to a depth of 6 ins. with finely divided sulphur. The lake as a whole was milky blue in colour, but with a broad band of red round its border. The red colour was due to a carpet of gelatinous material which lay on the bed of the lake in shallow water. It was red on the top and black and green underneath. A well-washed sample was examined and found to consist mainly of pink cells. This is probably a species of organism which produces sulphur from the sulphide in the presence of light and deposits it *inside* the cell. The green colour was produced by other organisms which rapidly oxidise sulphide to sulphur and deposit it *outside* the cell and they are probably the chief agents responsible for the sulphur at the bottom of the lake.

This formation of sulphur has since been reproduced in the laboratory by inoculating an artificial lake water, based on an analysis of the original, with the red and green material and crude cultures of sulphate reducers. A good yield of sulphur was obtained. It may be possible to develop an industrial process based on what takes place in the lakes. One small lake contains about half a million gallons and produces about 100 tons of sulphur a year. The major part of the research to be carried out must be concentrated on speeding up this process to an economical level, probably about ten times its present rate. It might also be possible to exploit natural waters and in this case the time factor would not be so important. Sewage is an excellent medium for sulphate reducers and it might be possible to contaminate lakes in desert areas to facilitate large scale production of sulphur. This is, of course, a highly speculative idea, but it could be tested easily enough.

The expedition had one immediate result. The scientists found that sulphur was being imported from Italy to Libya for use in dressing vines at a cost of £80 per ton. Previously they had seen dumps of crude sulphur near the lakes which could be delivered at Benghazi at £20 per ton. The annual figure for dressing vines was estimated at about 50 tons and as the lakes produced about 200 tons a year there was more than enough to supply these requirements. Experiments would be necessary before using the crude sulphur on a large scale but there is no reason to suppose it is unsuitable and its use would save the country several thousands of pounds each year.



One of the key bacteria in the biological production of sulphur (*Desulphovibrio desulphuricans*). Magnified 10,000 times.

The Wandering Eye

THE human eye has, for simple exposition, often been considered as a fixed optical system consisting of a lens and a screen (the retina) at a fixed distance away consisting of a multitude of light-sensitive units (rods and cones).

Normal experience, however, shows that this picture of the eye, though correct as far as it goes, does not account for all the phenomena of vision. One of the factors that make the system different from that of a fixed optical arrangement like, shall we say, that of a camera, is the movement of the eye going on all the time, even when the eye is supposedly 'fixated' on a small object. Anyone can check a very simple example of this fact by making use of the after-image phenomenon. You look at a bright source—a coloured patch, or the sun, or an electric light, for example—for some time and then look at a white surface. A 'negative' after-image is seen, that is, one whose colour is complementary to that of the source originally looked at. If, for example, the object fixated is the setting sun, a reddish disc, the after-image is greenish. One interesting fact is soon discovered about this image—it does not stay still but wanders about, and a definite effort is needed to make it stay still. This wandering of the after-image is an instance of the involuntary and normally unfelt movement of the eye. In reading, too, the eye makes sharp movements, the so-called 'saccadic' movements, along the line of print and stays for a moment fixated between each small sweep.

The examples given by no means exhaust the phenomena involving eye movements. A number of people have therefore tried experimental techniques for observing and sometimes measuring these movements. Scientists such as Helmholtz, basically a physiologist, and psychologists like Dodge experimented in the past. Helmholtz used after-images; Dodge and others since have used the reflection of a spot of light from the cornea (the transparent material

covering the front of the eye) to make a record of eye movements photographically. The eyeball when it moves actually swivels—all movement of the eye is rotatory, and the distance from the front of the eye to the centre of rotation is so small that an angular movement of as much as one degree produces a movement of any point on the cornea of only about 0·2 millimetre. Many movements entail rotation of the eye through less than one degree, and some of the experimental techniques already used, though successful for recording comparatively large movements of a degree or more of angle, have been limited in their scope because they were not sufficiently refined. Adler and Fliegelman in America developed a method for recording movements as small as a minute of arc by attaching a small mirror to an anaesthetised eye and recording photographically the deflection of a beam of light reflected from the mirror, somewhat in the way that a beam of light is used in a mirror galvanometer for magnifying small movements of the coil. This was in 1934. Not long after this Dr. W. D. Wright of the Imperial College of Science and Technology in London was working with Dr. Granit, the well-known Swedish physiologist whose researches on the nerve fibres of the eye-system have provided data of great significance for all scientists concerned with problems of vision. It seemed likely at this time that the response of the retina to differences in light might not be a static one but a dynamic one in which the eye was, so to speak, scanning a scene and responding to sudden changes in light energy. It was then that Dr. Wright first thought that a refined technique was needed for the study of many problems involving eye movements, a technique that would allow of permanent records of movements as small as one minute of angle and interfere as little as possible with the natural state of the eye—a condition not satisfied by methods involving the fixing of a mirror or a dab of paint or a plaster ring to the cornea. In addition the difficulty presented by tiny movements of the whole head, movements likely to complicate the records of eye movements, had to be overcome. These head movements had been ignored by Adler and Fliegelman and some earlier workers using somewhat similar techniques.

This work was given to Dr. Mary Lord, who has now worked for some five years on the problem at the Imperial College of Science. She has developed a method of refinement and flexibility, not limited to one type of eye movement. In the first experiments the subject whose eyes were under test had to lie supine with his head supported in a sling and resting on a support while his teeth bit on a plate of dental wax made especially for him to suit his tooth formation—this ensures that the head is always in the same position for every experiment—and he fixated his eye on a target. Obviously, the subject had to be skilled for the work to have any value. It is no secret that the principal subjects were Dr. Wright and Dr. Lord themselves, with afterwards other willing helpers, including one who suffers from nystagmus—an affliction in which tiny continual oscillations of the eyeball take place from side to side. In later experiments the subject has been able to remain upright.

A very brief outline of the technique can be given. A beam of ultra-violet light is directed on the cornea in such a way that any light penetrating the eye falls on the blind spot of the retina. The subject is thus unaware of the stimulation except for the consciousness of a slight blue haze caused by fluorescence from the ultra-violet light irradiating the retina. The beam reflected from the cornea is divided into two by a half-silvered mirror. One-half is directed past a vertical straight-edge (actually a razor blade) and the other half against a horizontal straight-edge. Thus any horizontal movement of the cornea changes the amount of radiation passing the vertical straight-edge, and any vertical movement changes the amount of radiation passing the horizontal straight-edge. Each beam is then directed to a photocell, which changes the ultra-violet-light energy into electrical energy. This is amplified and then carried to a cathode-ray oscillograph. On the screen of each oscillograph there appears a vertical movement of the light spot depending in length on the amount of energy fed through the amplifier. By means of another half-silvered mirror each beam from the screens, each one a beam of visible light by now, is directed to a photographic film moving continuously in a horizontal direction. During an experiment, therefore, there are two traces on the film, one for each oscillograph. Vertical movements on one trace correspond to vertical movements of the cornea and vertical movements on the other trace correspond to horizontal movements of the cornea. The film speed is accurately known and calibrated, and the vertical movements corresponding to cornea movements of as little as one minute of angle are also calibrated. So the size and time of duration of the movement of the cornea can be measured. The record is permanent.

Head movements alone were first measured in order to be allowed for in later experiments. They were first detected by the use of an artificial cornea supported on a spectacle frame just above the live cornea, but this method was later modified to obtain a more rigid connection of the artificial cornea to the head. It was found that the head executed a vertical movement up to 0·01 millimetre in time with the heart-beats and a horizontal movement rather bigger. (Although it does not appear in the published results, there are also movements corresponding to breathing rhythm when this is exaggerated. This fact was found when one of the subjects, being late, hurried from South Kensington station to Imperial College and was immediately tested.) The 'bumps' in the recorded trace caused by head movement can be picked out fairly easily and distinguished from those due to eye rotations only. Interpretation of the latter has shown that the eye executes rapid flicks lasting for about a fiftieth of a second and extending over several minutes of angle when the eye is supposedly fixated on a target. These flicks occurred twice a second for one subject and three times every two seconds for the other.

The apparatus has been modified to allow measurement of larger angular movements of the eye and to be free of the limitation to horizontal and vertical movement only, and experiments have been done to examine the movements when the subject transfers his attention to a different point and when he follows the movement of an oscillating object such as a pendulum. Tests have also been made with the subject reading. It has been found that when one subject followed the movement of a pendulum his eye executed a rhythmic and continuous movement, whereas when he transferred his attention from one fixed point to another repeatedly, backwards and forwards, though he

felt that his eyes were following smoothly and continuously, they were in fact moving in short jerks with intervals of fixation. While reading print, the same subject was found to make eye movements not only of the known saccadic type but also a continuous sweep downwards while travelling along a line of print, an observation never previously recorded by any worker.

The results achieved so far are related to very simple phenomena and are restricted to a few subjects. It seems likely that the technique developed, probably more adaptable and more sensitive than that of any other worker, can now be used with many subjects in order to get results that can be generalised. It can also be applied to more complicated problems such as those of convergence and stereoscopic vision as well as to problems of interest to psychologists and ophthalmologists.

Insect Control by Virus

THE European Spruce Sawfly, formerly known as *Dyprion polytomum*, and now as *Gilpinia hercyniae* looks like providing a classic instance of the biological control of an insect pest, not only because of the vast scope and intricate nature of the problems involved, but also because it has entailed the use of a new type of organism for this aspect of applied biology: control by virus disease.

The story of the pest starts in Canada some twenty years ago, when severe defoliation of certain species of spruce was found to be occurring in the Gaspé peninsula of Quebec Province. So rapid was the spread of the pest that by 1931, aerial survey had shown an area of some 2000 square miles to be affected, while the infestation was spreading rapidly to other tracts of spruce forest. Although the sawfly, whose larvae feed on the spruce needles, does not itself kill the trees, the defoliation so weakens them that they become disastrously susceptible to many other pests, notably bark beetles and woodborers, whose attacks may result in the death of 75% of the trees in a given area.

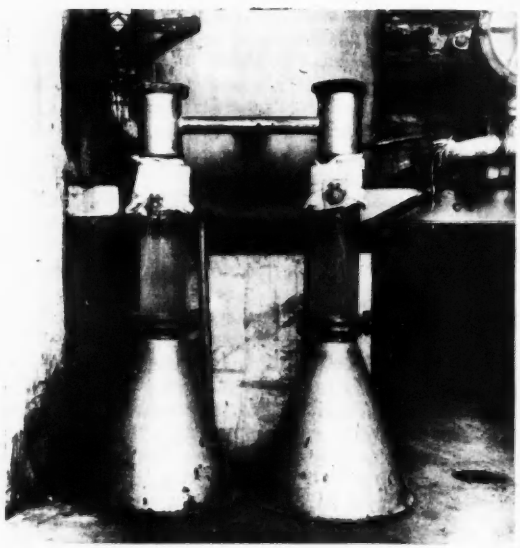
The early stages of control of this pest showed the usual features of biological warfare; the search for the insect in its native habitats, the spruce forests of northern and central Europe; the collection there of parasitised material, the shipment of this and of parasites to the affected area, the breeding and liberation of large numbers of the parasite species. This proved, up to a point, successful, and in fact by 1938 several of the introduced parasites, notably a eulophid, *Microplectron fuscipenne* (whose name has recently been changed to *Dahlbominus fuscipennis*) and an ichneumonid *Exenterus marginatorius*, were beginning to make themselves felt in reducing the sawfly population. By 1940, 392 million of the first of these parasites had been liberated in Canada alone, and it was beginning to be used on a big scale in the northern states of the U.S.A. as well.

It was about this time, however, that a new feature was noticed which has altered the whole aspect of biological control. In U.S.A. (1937), and Canada (1938), an agency known at first as 'wilt disease' began to appear as the cause of death in increasing numbers of sawfly larvae. First observed in Canada, under laboratory conditions, it had all the characteristics of a virus infection, and similar effects to those known in parallel conditions with various lepidopterous larvae. So effective was this disease in reducing the sawfly population that Dominion entomologists were quick to seize upon its possibilities. Tests were made by spraying areas in which it did not occur, with an extract of diseased larvae, while in affected areas the incidence of the disease was increased by similar means. By 1941, this disease, which had come to be known as 'polyhedral virus', was the chief means of sawfly control over a large part of the infested areas of both Canada and the U.S.A. It was shown that the larvae become infected by feeding on foliage with which the virus has been in contact, and the virus itself can be spread aerially from larval remains or excreta. Only the first five instars of the sawfly larvae, however, are attacked, since it is only then that the larvae feed; but once attacked, the larva may carry the virus right through successive stages of its development (if it does not die in the meantime) until the emerging adult insect may itself be contaminated. It is even possible that the disease may be carried through to the next generation. Cases of individual immunity to the disease, and even of resistance, have not so far been noted.

This virus disease, spreading either naturally or through spraying of the extract from diseased larvae, has now become the major controlling factor in spruce sawfly outbreaks, but this does not mean that the problem of the sawfly is solved. The virus, for example, is effective where populations are most dense, while already in some areas its efficacy is decreasing. This has an important bearing on the parasite population also. At one time, it seemed possible that parasites alone would be able to achieve the 97% mortality which it was considered would be necessary before the sawfly had settled down to a static population so low as to be unimportant as a pest. Now, the absence of food (in the form of sawfly larvae) due to the virus disease, itself limits the numbers of parasites, and a different balance is likely to be struck. In general, however, it is shown that the two parasites already mentioned, and another, a tachinid fly of the genus *Sturmia*, are able to survive even where the numbers of sawflies have been greatly reduced. This means that when the virus disease becomes less effective, the parasites will take control again, and it looks as though in this way the problem of this disastrous pest of one of Canada's major timber stocks, will be solved.

The implications of this story are obvious. Already, biologists from Canada have been investigating in Europe —the home of both sawfly and, it is considered, the virus disease—the possibility of finding other similar controlling organisms. It may be that diseases of this type are responsible for the control of very many insects which might otherwise assume pest status, and which in fact do so, when introduced into new areas. It may be possible to find other virus/parasite/host complexes which will reach a balance at which the pest insect is no longer of economic importance. Such combinations of natural control methods would, for example, seem much more satisfactory than the systemic insecticide/parasite relationship suggested recently at the British Association. The immense possibilities if such a method could be applied to major world pests such as locusts, or Colorado beetle, do not need emphasising. But what is encouraging, at the present stage in the history of international relations, is to note that virus warfare, at least, has been first used successfully by Man against his insect enemies, rather than against his fellow human beings!

FIG. 1 (*left*).—Bulgaria supplies most of the world's rose oil. Two oil-producing roses are harvested, the red *Rosa damascena* and the white *Rosa alba*.



FIGS. 2 and 3. Distillation of the rose oil.

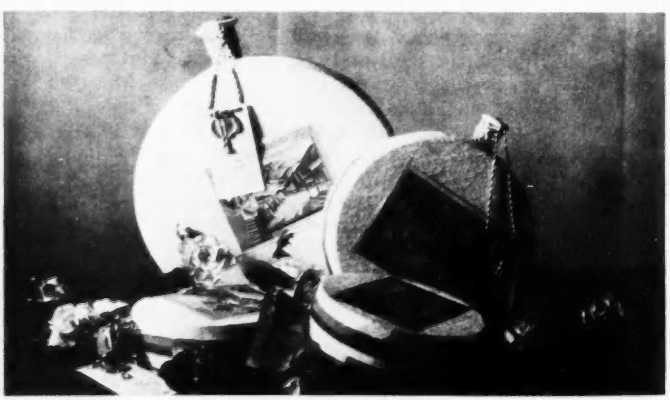


FIG. 4 (*left*).—Rose oil in the original containers bearing the seal of the Bulgarska-rosa, the state marketing organisation.

PRODUCTION OF ROSE OIL

ONE of the
world is to
the sensati
tions with
is an aesthe

Whilst m
flowers, so
been garne
"Why do
wider impl
perfume re
These can
known as
essence of
scent is los
the essence
prime, for
are picked
season whe
they can be
they have t

Separatio

Various
oderiferous
very gentle
delicate and
are chemica
presence of
smell either
odour. Th
distillation,

Distillati
tracted by
must be fre
leaves, etc.
i.e. in steam
distil over
would requ
them. Hig

The bull
Attar and
where grea

Sometim
are so easil
a partial va
distil over t
Irone, whi
distilled in
procedure
the true vio
which has
relatively c

Enfleurag
petals of fl
oils pass fr
such as de

Flowers and Their Perfumes

R. W. MONCRIEFF, B.Sc., F.R.I.C.

ONE of the purest pleasures that is to be experienced in this world is to savour the fragrance of flowers; for most of us the sensation stimulated by their perfume has no associations with any of our workaday problems and desires; it is an aesthetic pleasure that can be enjoyed for its own sake.

Whilst much remains still to be learnt about the smell of flowers, some quite interesting information has already been garnered. The first question one would raise is, "Why do flowers smell?" Ignoring for the present the wider implications of such a query, one can say that the perfume resides in the oily constituents of the flower. These can often be separated from the flower and are then known as its essential oil, inasmuch as they contain the essence of the flower. Flowers fade and as they do their scent is lost, so methods have been devised of separating the essence from the flower whilst the latter is still in its prime, for it is then that the perfume is at its best. Flowers are picked for separation of their essential oils in the season when they are most abundant, not only because then they can be obtained most cheaply, but also because then they have the finest smell and the highest content of oil.

Separation of Essential Oils

Various methods have been developed for extracting the oderiferous oils from flowers; all these methods have to be very gentle in their action because the essential oils are delicate and easily decomposed. Many of their constituents are chemically unsaturated, so that if they are heated in the presence of air they are readily oxidised; on oxidation their smell either disappears or is converted into a flat indifferent odour. The three general methods that are adopted are distillation, enfleurage and extraction.

Distillation.—Probably the bulk of floral oils are extracted by distillation. The flowers, newly picked, for they must be fresh to have the finest odour, and free from twigs, leaves, etc., are loaded into a still and distilled from water, *i.e.* in steam. Many of the oils are volatile in steam and distil over with it, whereas in the absence of the steam they would require very much higher temperatures to volatilise them. High temperatures must be avoided.

The bulk of the world's Oil of Roses, also known as Attar and Otto of Roses, is made by distillation in Bulgaria where great quantities of *Rosa damascena* are grown.

Sometimes the chemical constituents of essential oils are so easily damaged that distillation is carried out under a partial vacuum; the purpose is the same throughout, to distil over the volatile oil at the lowest feasible temperature. Irone, which is the basis of the best violet perfumes, is distilled in this way from the rhizomes of *Iris florentina*; this procedure is necessary because α- and γ-irones which have the true violet odour readily change on heating to β-irone which has a vastly inferior perfume, more resembling the relatively cheap synthetic ionones than true violet.

Enfleurage.—This process consists of spreading the petals of flowers on trays of grease. The volatile essential oils pass from the flower petals to the grease (animal fat such as deodorised lard) and after a time the exhausted petals are removed and replaced by a supply of fresh petals; this process is continued until the fat becomes so heavily laden with the essential oil that it will no longer efficiently remove it from the petals. Then the fat is extracted with a low boiling solvent, such as alcohol, and the solvent is removed by evaporation, preferably under vacuum. The residue contains a good deal of fat as well as the essential oil and is known as a 'floral concrete'. It is partly used in this form and partly extracted with alcohol, which dissolves all the essential oil but very little of the fat; then the alcohol is evaporated and what remains—the true essential oil—is known as a 'floral absolute'; as such it is highly prized and very expensive. Enfleurage is an expensive process and it is adopted mainly when any heating (and some is essential for distillation), would be harmful to the odour. Jasmine absolute is made by enfleurage and so is a small proportion of rose oil. The process is nearly obsolescent.

Extraction.—Flowers can be directly extracted with low boiling solvents which rob them of their volatile oils, and then on evaporating the solvent the oil remains.

Adsorption.—The essential oils consist for the most part of water-insoluble substances which are strongly adsorbed by activated charcoal. Various processes have been suggested to make use of this property. It has for example been declared that flowers only exhibit their finest odour whilst they are growing, so that if some strongly adsorbent material such as coconut charcoal were placed near beds of flowers or in greenhouses, the scent could be adsorbed in its most perfect form, later to be removed by submitting the charcoal to the action of steam. Then again flowers that grow profusely in tropical and industrially undeveloped countries could be treated with charcoal where they were grown and the charcoal plus its adsorbate shipped home for treatment. The process strongly resembles enfleurage and has two advantages over it: firstly, activated charcoal can make much more intimate contact with flower-petals than can grease; and secondly, the charcoal is chemically stable whereas grease is liable to turn rancid, with disastrous effects on the odour of the floral essence.

Whatever the method, care must be exercised to prevent oxidation, or polymerisation, as either change will almost certainly greatly diminish the odour; often, yield has to be sacrificed to get the best quality. For example, an oil with an exquisite floral odour is made from ylang-ylang (flower of flowers, or *Canangium odoratum*) by distillation, but when only two-thirds of the oil has distilled the receiver must be changed. The first fraction is the highly esteemed ylang-ylang but the last fraction is the much inferior Cananga oil; if all were collected together, it would all have to be sold as Cananga. The manufacturer has constantly to remember the precious and unstable chemical characteristics of the flower oils.

Composition of Floral Oils

Chemists have endeavoured to analyse the chemical composition of individual flower odours. Sometimes this has proved to be fairly straightforward; at other times

unexpected complications have ensued. The main constituents of rose oil are easily identified as citronellol, geraniol and nerol; all three are unsaturated aliphatic alcohols with ten carbon atoms in the molecule, and all three having characteristic rose odours. Citronellol is present in greatest quantity, often from 30% to 50%, and it has the odour one associates with scented dark red roses, whilst geraniol has the lighter 'wild rose' odour. One other component is essential to support the trio, namely, phenylethyl alcohol. When the oil is distilled with steam from roses, the phenylethyl alcohol being water soluble is lost from the oil because it dissolves in the aqueous layer—the rose-water. But different varieties of roses have very different smells; Madge Whipp, a red rose, has a fine scent characteristic of the fragrant deep red roses, but Christopher Stone, another red rose very similar in appearance, has only a poor scent; Lady Pirrie, a creamy-pink variety, has a light but delightfully volatile scent; Poulsen Yellow, a polyanthus rose, smells like the wild rose but more strongly; Frau Karl Druschki, a superb white, is quite odourless.

No oil is ever extracted from violets, but it is believed that the essential odorous principle of violets is irone, a substance which occurs much more plentifully in orris root so that 'oil of violets' is distilled from this source only and not from the flowers.

Orange blossom yields an oil known as oil of neroli, one of the essential constituents of eau-de-Cologne. The characteristic odour of oil of neroli and of orange blossom is due to an ester it contains, methyl anthranilate, one of the few nitrogenous esters used in perfumery. By way of example, oil of neroli contains about 3% of methyl anthranilate, about 25% of esters, mainly linalyl acetate, and about 55% of alcohols, the most abundant being linalol.

Usually it is a fairly simple matter to identify the essential characteristic odorous component, the citronellol in the rose, the irone in orris-root, and the methyl anthranilate in orange blossom but in some flowers it is not so easy. Lavender, for instance, has a fine characteristic smell, and one which reappears even more strongly in its oil, but this scent is due not to any one component but to the general ensemble of linalol and geraniol and their acetates, butyrates, valerianates and caproates; no one individual component has the lavender smell.

Natural flower perfumes are complex mixtures. Oil of ylang-ylang has already yielded more than thirty separate components to the analyst, and there are probably still other odorant materials present in traces, but not yet identified. The relative proportions in which the odorant components of a flower are present vary from one variety to another, according to where the flower is grown, even according to the altitude in the same district. Lavender is a case in point; English-grown lavender oil is much more highly esteemed and very much more expensive than the French.

Synthetic Perfumes

Having ascertained the nature of the main constituents of the essential oils from some flowers, the chemist automatically thought of synthesising them and so replacing much more cheaply the floral absolutes. When one knows that a ton of roses gives only about a pound and a half of oil, it is easy to realise that natural oils made from flowers are expensive; there was every incentive for the chemist to synthesise them. In some measure this was easy enough and the chemist met with early success. Phenylethyl alcohol, a natural constituent of the rose and one that is ordinarily lost in the rose water is easily synthesised from coal-tar derivatives; so is methyl anthranilate which can be synthesised from naphthalene which is first converted to phthalic acid, and this to anthranilic acid which is esterified by a standard reaction. The phenylethyl alcohol and the methyl anthranilate which are synthesised from coal-tar products are indistinguishable from the same chemicals isolated from the floral oils. Sometimes a partial synthesis is used; it would be quite costly to synthesise citronellol from simple laboratory reagents, but a closely related compound known as citral occurs to the extent of 70% in oil of lemon-grass (an oil which as its name implies is obtained from a species of grass), and the cheapest and best way of making citronellol is to isolate the citral from lemon-grass oil and then to convert it to citronellol via the aldehyde.

Perfumery chemicals can be made much more cheaply than oils can be extracted from flowers. Most of the oil of rose used today is built up from synthetic citronellol, geraniol, etc., but the last nuance of perfume defeats the perfumer even today. It is almost impossible to hit just the right note; a really good synthetic otto of roses will still have to have added to it 10% of natural otto. Nature is not usually simple, and flower scents depend for their shades of perfume on the presence of traces of diverse substances; the chemist can build up 90% of the perfume but the last touches must come from Nature. Of course cheap perfumes are wholly synthetic, but they could seldom be mistaken for the natural product.

Some chemicals too, although identified quite early, have proved difficult to synthesise. Irone, the essential true violet perfume, was isolated by Tiemann and Kruger in 1893, but it was not until November 1947 that its synthesis was first described. Rather oddly, in the same issue of *Helvetica Chimica Acta* that reported this achievement the synthesis was independently described by two of the greatest of contemporary organic chemists, Dr. Y. R. Naves and Professor L. Ruzicka. It is strange that a synthesis for which the perfumery world had waited for fifty years should have been achieved simultaneously and independently.

It would not be easy to refute the suggestion that flowers were created and given scent in order to delight the inhabitants of this planet. The scientist, however, would indicate that flower scents have a value to the plant and assist in its two primary aims; these are self-preservation and reproduction of the species.

Some of the odorous constituents of floral oils have strong fungicidal properties and these protect the plants from fungal attack; the anthranilates and the anisates in particular are endowed with this property. The first insects appeared on the earth before the first flowering plants, but during most of the time that there have been insects flowering plants have existed. The evolution of these two great groups of living organisms has been interconnected in a remarkable fashion. As the late Prof. G. H. Carpenter has said: ". . . . the rise and development of the

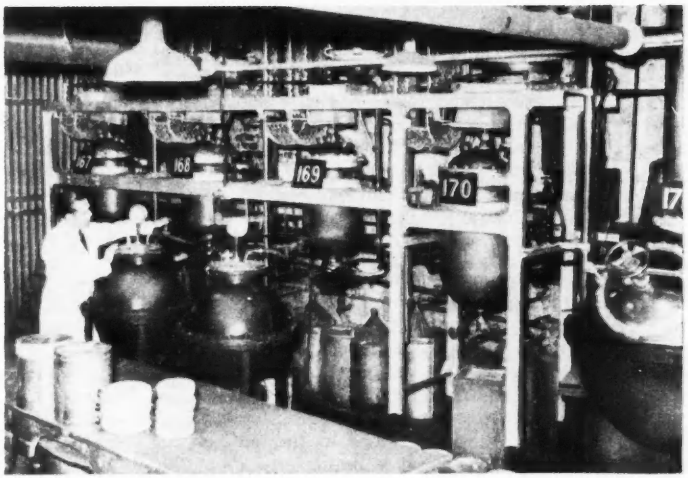


FIG. 5.—A modern distillation plant for the preparation of floral absolutes. (*Photo by W. J Bush & Co. Ltd.*)

flowering plants (has) been brought about concurrently with the specialisation of those groups of insects among the Hymenoptera, Diptera and Lepidoptera that seek in blossom for their food. The relations between such insects and flowers are among the most remarkable of associative features shown by living beings, and suggest irresistibly that the insects and plants have grown, as it were, to fit each other in the course of their long histories."

Today flowers and insects are mutually indispensable; the flower provides food for the insect in the form of nectar and pollen, the insect pollinates the flowers as it flits from one to another. Insects have their favourite flowers; the moth *Micropteryx calthella* is an example, for it visits only buttercups. Sometimes the insect's apparatus for nectar-sucking has become adapted to use on a particular species of flower, and nectar that is inaccessible to most insects will be accessible to only one variety of insect.

Considerable discussion has taken place as to the relative importance of flower colour and scent as attractions for insects. Some insects respond chiefly to scent; for instance, Kerner observed that the convolvulus hawk moth when released out of sight of honeysuckle blossom will fly direct to the flowers a hundred yards distant. With bees colour is of more importance; Werry exposed various flowers about five yards from a beehive in an otherwise bare field, and she found that the highly coloured but almost scentless flowers of dahlias were visited by 35 bees as against 6 bees which were attracted to the very odoriferous but inconspicuous flowers of mignonette.

Some flowers such as the night-scented stock and tobacco plants which open and shed their perfume at night are pollinated by night-flying moths.

There are other flowers which have odours that to our sense of smell are repulsive and nauseating, and yet which serve to attract insects. *Aristolochia labiosa* smells like spoiled lobster, and the serpent arum, *Arum dracunculus*, smells like a putrescent corpse. Fabré recorded how hordes of beetles such as ordinarily scavenge the corpses of frogs, adders and hedgehogs invaded a serpent arum and how, intoxicated by the delicious corpse-like odour, they swarmed and rolled, seethed and boiled, clicked and squeaked until they perished. The stench of the stinkhorn *Phallus impudicus* attracts blowflies which feed on the slime that covers the cap of the fungus and carry away with them and disseminate the spores embedded in it.

In the woodruff *Asperula odorata* scent only appears when the leaf is withered and in other leaves, too, scent is only set free after the death of the plant—dying wild strawberry leaves have a cordial smell. In some such cases it has not been easy to see the significance of the appearance of odour, and it has been a little lamely attributed to waste-products. It is easy to say that the ordinary flower is a mechanism called into being by the nectar-feeding insects which fertilise it and that colour, form, and scent of the flower are adapted to the one end of attracting insects that visit it, and effect cross-fertilisation. So much is well understood, but there are other functions of flower scent that are still largely hidden from us.

One final point remains to be clarified. We recorded above that a moth had flown straight to a honeysuckle flower that could not be seen from the point of flight. This surely suggests a great acuteness of smell, and in fact moths and butterflies have a sense so sensitive that it might be quite different from our olfactory sense. In the 'assembling' of moths, males will detect a female several *miles* away; there is no doubt about it, for there are many well-authenticated cases. And, too, it is truly smell, because the odorous substances can be extracted from the female moths, and the chemical extracts so obtained will attract male moths from miles around. However that is another subject.

Figs. 1–4 by courtesy of *The Perfumery and Essential Oil Record*.

READING LIST

F. A. HAMPTON, *The Scent of Flowers and Leaves*, Dulau & Co. Ltd., London, 1925.

R. W. MONCRIEFF, *The Chemistry of Perfumery Materials*, United Trade Press, London, 1949.

W. A. POUCHER, *Perfumes, Cosmetics and Soaps*, Chapman & Hall, London, 3 vols., latest edn., 1942.

H. S. REDGROVE, *Scent and All About it*, Heinemann, London, 1928.

MACGREGOR SKENE, *The Biology of Flowering Plants*, Sidgwick & Jackson, London, 1948.

Radio provides one of the important media for publicising scientific work. In the last issue we mentioned the lack of a guide to the preparation of radio scripts, and this article by Dr. Archie Clow, producer of the BBC's Science Survey and Science and Everyday Life series is designed to fill this gap.

Science by Radio

ARCHIE CLOW, M.A., Ph.D., D.Sc.

THE variety of ways in which science can be put on the air appears at first sight to be almost limitless, but basically they all boil down to two. Either the scientist performs himself, that is, he gives a talk or enters into a discussion, or he provides material that has to be presented by professional actors. The scientist himself may, of course, be the writer of such a 'feature script', to use the technical term. Both these methods are used by the BBC in the presentation of science, but it is particularly about the activities and performance of the scientist himself that we are concerned here.

During the past five years I have been present at the birth of hundreds of science broadcasts, and some of my experience may interest those involved in the presentation of science to a mass audience. Nothing that follows is intended to be dogmatic: it is merely a record of experiments designed to establish canons of good science broadcasting.

First then, what are the criteria by which we may assess a scientist as a potential broadcaster? It is true that in practice such a decision may at times be arrived at subjectively without conscious analysis, but on examination the essential qualifications seem to resolve into the need for four essential qualities. The potential broadcaster must have something worth while to say. There is not always a high correlation between this and a desire to get on the air. The scientist must be able to put that something on paper imaginatively. Research reports do not as such make good broadcasts. Thirdly, he must be able to perform from his script. This word *perform* is used advisedly because the radio talker becomes in the end an actor, acting himself, it's true, but in the interests of good radio perhaps just a little larger than life.

But a satisfactory compliance with these three criteria will not necessarily get a potential broadcast on the air. With the intense competition for space on the air there must always be a valid reason for informing the public about that particular topic at that time. Many science broadcasts have, even if only vaguely, a news value. The possibilities of giving a talk today on, say, penicillin would be quite different from those of four years ago.

Also, the relative importance of these four factors varies considerably in relation to the requirements of the Home, Light, Third and Overseas services of the BBC.

Assuming that the above criteria have been satisfied and that you are faced with giving a broadcast—what then? Let us consider the medium we're working in.

Information, pleasure, entertainment, what you will, may be transferred from person to person in a variety of ways—through the stimulus of direct conversation and discussion, or by a lecture, by reading a book, seeing a film or listening to the radio. Suppose we take the radio situation to pieces and see how it differs from the other ways of establishing contact between two minds.

Almost always the first reaction on the part of the speaker invited to broadcast is for him to be overawed by the vastness of his unseen audience, by the figures that are given for the number of licence-holders—eleven million or whatever it is. Also sometimes by what his scientific colleagues will think. But of these many million ordinary listeners only a fraction will be listening at one time. Perhaps only 5 per cent. That, however, is beside the point. The million or so who do listen to a science broadcast do not listen as one vast audience. They listen in very small groups—twos and threes. A group of more than three must be quite exceptional except in such cases as organised broadcasts to schools and the Forces. So listeners are grouped in their twos and threes—and, moreover, they're listening in their own homes—and to you. To you, the speaker, directly. There is it is true much elaborate electronic gear between you in the studio and the listener at his fireside, but for all that there is less of a barrier in the radio situation than is imposed by, say, a book. So here emerges a fundamental canon—the importance of the intimacy of the medium.

What does this imply? It implies that to give a successful broadcast you have to establish yourself within the home of the listener, and usually with a single person. How would you behave in such a situation—certainly not as if you were on a platform, or behind the lecture table. So speeches and lectures are not radio talk. I think in such a situation you'd talk—not make speeches. You'd converse. You wouldn't say "Subsequently meteorological conditions deteriorated". No, you'd say "Then it began to rain". So there we get another aspect of the canon of intimacy—don't talk like a book—or worse, like a scientific paper!

There is more to it, however, than a difference between the spoken and the written word. Consider what a reader does when he gets a piece of printed matter, be it article, or paper, or book. I don't know what other people do, but speaking for myself, I'm sure I always go through a period (it varies in length) of what I'll call sampling the material. I look at the chapter headings, thumb it over, look at the illustrations, perhaps read the summary at the end, and only then get down to the serious work of reading continuously for information or pleasure. It's a pleasant way of filling in the psychologist's induction period, warming up to the ensuing activity. But you can't listen to the peroration to a radio talk first. Time flows on and so does a broadcast. From the word go it's take it or leave it, then or never, more or less. So here is another signal difference between radio talk and writing. You can have no induction period. A broadcast must start at such a

high level of interest that your listener is captivated right away and goes on listening instead of changing the programme or switching off. More radio talks have foundered in the first thirty seconds than possibly any broadcaster has ever imagined. The ear is perhaps better at doing without a warming up period than is the eye and it will respond properly if the writer will only make the right approach. But having settled down to read, the reader has one inestimable advantage over the listener. If he gets stuck he can turn back and re-read the difficult passage.

But there's no turning back a talk and if, for whatever reason, a listener misses a point, his flow of understanding will black-out for several seconds. So one transgression on the script-writer's part will be expanded in the listener's mind and he will miss more than the bit that was the actual cause of his losing the thread of the argument. So here we have a second canon—the material presented must be laid out in such a way that it flows smoothly and without irritations.

That brings us to the question of structure as a whole. It would be presumptuous to lay down any strict and fast rules about the structure of a script. Each occasion is a law unto itself, but the fact is that some structure should be there as a help to the listener to keep with you to the end. I've spoken about the vitally important first thirty seconds or so. Following that, one has then to realise that attention will ebb and flow and there are constant danger periods during a radio talk when interest may flag and be lost altogether if the speaker is not on his toes all the time. So a conscious effort should be made to keep the interest level high and provide milestones to guide the listener through the talk. One can also do a little turning back for him, and so on, always trying to preserve a sense of balance. It's true that when a specialist is writing a fifteen- to twenty-minute broadcast one of his greatest problems is the selection of material, but selected it must be, and the selection should be so arranged as to give a pleasing balance. The final stages of a broadcast filled with such phrases as, "Of course I can't go into it here, but it's important to mention . . ." do nobody any good. In fact they irritate. Far better cut them out and tie the available threads together. Repetition too is no sin. Quite the reverse, and in a situation where associated stimuli are lacking, it is in appropriate circumstances highly desirable.

In connection with this problem of script structure I'd like to quote the opening paragraph of a recent broadcast by Colonel Ian Boyd to the Forces. It was on reinforced concrete—not exactly an exciting subject—but in fact the broadcast was highly successful. It opened, after the usual announcement, like this:

"I expect that at some time you've seen those Chinese puzzles which start with a nice coloured box, or a tubby figure of a man. On opening the first box, you find a smaller one inside. That contains a smaller one, and so on, until after six or a dozen boxes you at last arrive at the centre of the puzzle. Well, the story of reinforced concrete is rather like that, because before I try to tell you about reinforced concrete, I've to explain what plain concrete is, and before I can do that I'll have to tell you about Portland cement."

And on the basis of that simple idea the speaker tied his whole story together. It gave just the coherence and structure that was needed to avoid a text-book-like treatment.

When one comes to actual language one is even more diffident about saying anything about the way in which a speaker's thoughts may be couched. Far be it from the BBC to want to impose standards of style, but there are certain considerations that cannot be neglected, the radio medium being what it is. If it is agreed that the medium is an intimate one then certain things follow. I think most experienced broadcasters will agree that it isn't far off the mark to say that, if you can say anything in a simpler way, still combined with elegance, then use the simpler way.

A self-imposed discipline will be the listener's gain. Polysyllables do not broadcast well: and the use of polysyllabic language to convey simple ideas is plainly foolish, albeit a prevalent vice. Doubtless you can think of many examples yourselves, but one I'd like to quote (it was used in one of the most august scientific institutions in Great Britain) is: "The cell became fifty per cent deoxygenated." I think "The cell lost half its oxygen" is just as elegant, and would have the advantage of being understood by many more listeners. If, of course, there is only one word to describe a situation, use it. If semipinacolinic deamination can only be called semipinacolinic deamination, well and good, but beware. Many of the words that seem to scientists to be in everyday usage are regarded as technical terms by millions of listeners. Words like cylinder, piston and crankshaft are by no means universally understood, even in the age of nuclear piles and jets.

Just what one is up against in putting over science will be realised when I give you some further actual instances of the difficulties. When a survey was made recently of groups of Forces listeners who had been listening to the BBC's regular *Science and Everyday Life* series, it was discovered that while the bulk of those questioned knew that microbes cause disease, rather less than half knew that living organisms caused the fermentation of beer and only about one in twenty that they are responsible for the souring of milk, this at a time of active campaigning to improve standards in the handling of food.

The BBC has, however, been carrying out a study of the intelligibility of educational broadcasts. This has been carried out by its Audience Research Department, and its Talks Department in co-operation with Professor P. E. Vernon of the Institute of Education. As reported in last month's DISCOVERY, nearly five thousand test papers were examined, of which a considerable proportion were related to science broadcasts. Professor Vernon presented the first of his results in a paper to the Psychology Section of the British Association at Birmingham in September. In essence he showed that the first essential in winning and keeping one's audience is a high 'interest-value' in the script. This is a complex thing still requiring further analysis but it clearly substantiates what was said above, namely, that an all-important factor is to have something to say. How to say it, seems, at the moment, to be much less important, for intelligibility at any rate.

But the real significance of these findings is that they are not confined solely to understanding the spoken word. They raise the most urgent questions with regard to the presentation of scientific information as a whole, and when the full results of Professor Vernon's investigations are

published they will undoubtedly provide much food for thought, and let it be hoped, future action. Then, perhaps, scientists (I quote *literatim*) will "start to discontinue" using long words, and we shall escape from the situation so aptly summed up by O. St. J. Gogarty: "Stone walls do not a prison make, but scientific terms do."

A SPECIMEN RADIO SCRIPT

The Riddle of Bird Migration

If you listen carefully these nights you will often hear the calls of birds flying high in the sky: calls that you do not hear aloft at most other times of the year. And if you live along the coasts you may see some usually deserted beach swarming with small drab-coloured birds that will stay for a few hours and then disappear as suddenly as they came. For this is a season of bird migration. From all over the southern world—from the Americas, Africa, Australia, New Zealand—birds are flying north. Some of them, as we all know, make voyages of many thousands of miles; others travel only a few hundred or even less. The British Isles are particularly well placed for the observation of these migratory birds because millions of them pass this country twice a year; once, in the spring, on their northward journey to breed during the Arctic or North British summer and the second time, on their southern journey back to their wintering grounds.

What causes migration? What starts the birds off? How can a tiny piece of living machinery like, say, a sanderling, or knot, keep going over such a long distance and, of course, how does it manage to find its way?

Men must have wondered about such things almost as long as men have wondered about anything. We know of the numerous references in the Old Testament to bird migration. This sort of thing: "For lo, the winter is past, the rain is over and gone; the flowers appear on the earth; the time of the singing of birds is come, and the voice of the turtle (i.e. the dove) is heard in our land."

Five centuries before the birth of Christ, the Greek Anacreon was writing verse about bird migration and the breeding seasons of birds. And of course, Aristotle and later, Pliny, also had something to say on the matter.

For centuries and centuries, men of learning thought that it was simply rising temperatures that started the birds off to visit a better place in which to breed and to find food. With the rise of modern science, however, such a primitive concept was not likely to last for very long; and in the early days of this century we find the distinguished physiologist Sharpey-Schafer writing to the technical journal *Nature* suggesting that changes in the length of the day might determine bird migration. Everybody by then knew of the extraordinary regularity with which birds started off on their journeys, and it seemed that the day-length factor was the only one that was sufficiently constant to explain this regularity. Although as early as 1824 Jenner—celebrated for his work on smallpox—had, in a communication to the Royal Society said that "certain periodical changes in the reproductive organs are the inciting causes of migration", Sharpey-Schafer did not think so because he saw that the reproductive organs of birds were still quite small when the birds reached their destination. Then, about twenty-five years ago, a then young zoologist, William Rowan of Alberta, performed some remarkable experiments that are a milestone in the literature of bird migration and the breeding seasons of animals in general. Rowan took a lot of migratory finches, exposed them to additional rations of ordinary white electric light and showed that by merely snapping on electric switches he could control the northward migration of birds. This is what he discovered. He found that birds that were exposed to additional light in the middle of winter started to sing, and developed nuptial and migratory tendencies even at temperatures of about sixty degrees below zero. And examination revealed that their reproductive organs had developed tremendously at the same time. So it all now seemed rather simple; light naturally increased in duration during the spring, this in some way caused the reproductive parts of the birds to develop and by some means started the birds off on their long flight north to their breeding grounds. Of course, there was still that perplexing southern trip to be considered. Some people suggested that it was decreasing light in the autumn that started them off back again.

Meanwhile, much enormously interesting work was being done by physiologists on the reproductive processes of animals. The detailed study of the endocrine glands was now under way. An endocrine gland is a gland without a duct; it pours its secretions straight into the blood stream and so the secretions are carried in the blood just as surely as, say, oxygen is carried. These secretions or hormones soon reach other glands or structures and act upon them. Now one of the most vital of these small glands is the anterior pituitary gland which is situated in various animals (including humans, of course) just below the brain and above the roof of the mouth. It was suggested that when light fell on an animal's eye or when its nervous system was stimulated in other ways, an impulse was conveyed to a part of the brain just above the anterior pituitary and soon that gland itself was stimulated in turn to produce its secretions.

These flowed through the bloodstream of the bird (for example) and so reached its reproductive organs, which were caused to develop. They produced sex hormones and the bird began the journey northward to its breeding ground, often many thousands of miles away.

Within certain limits that seemed reasonable enough. But there now arose a school of thought that discounted all this because although the reproductive parts of birds increased by several hundredfold in the spring, they were demonstrably still very tiny *at the time when the birds started off for their journey to the breeding grounds in the north*. Therefore, it was argued, it could not be caused by sex hormones. It was known that migratory birds deposited in their bodies an extraordinary amount of fat before they left; so (to over-simplify) some people said that this fat deposition was a partial cause of migration, even though nothing special has been discovered about the chemical composition of the fat. Again, others reasoned

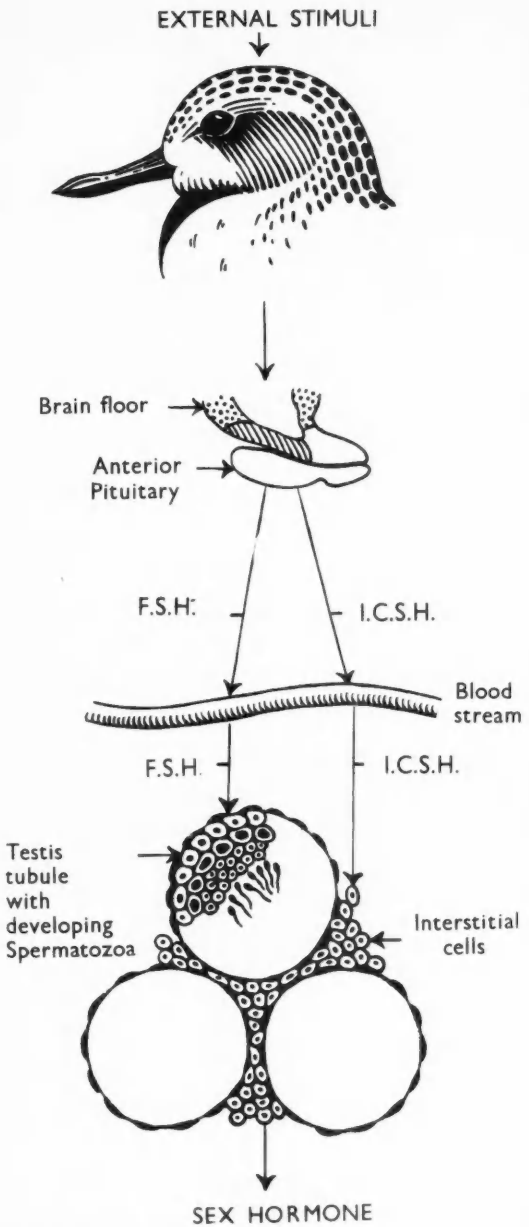


FIG. 1.—Diagram showing some of the suspected mechanism of breeding in the male bird. Stimuli from the environment are received by the central nervous system and the internal endocrine machinery begins to tick over. The production and liberation of sex hormone leads to 'instinctive' movement to the traditional breeding site. There is an internal rhythm of the testis which is ultimately controlled by external (environmental) factors and thus the breeding season is kept anchored in time. Reproduction usually occurs in spring when there is plenty of the specialised food that is necessary in large quantities to satisfy the ravenous young and to bring them safely to maturity. F.S.H.=follicle-stimulating hormone; I.C.S.H.=interstitial cell stimulating hormone.

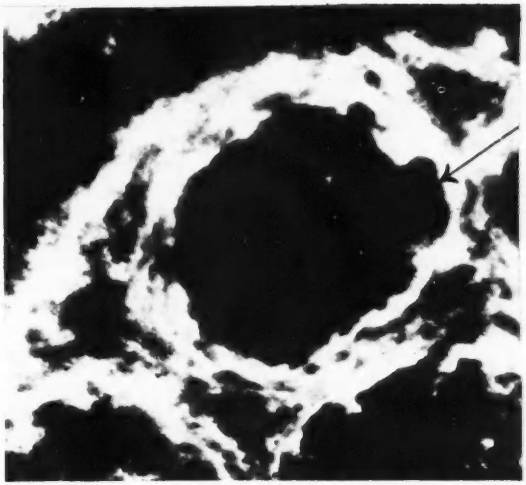


FIG. 2.—After the breeding season the germinal tubules undergo a striking metamorphosis and become crammed with fatty material. Arrow points to a tubule coloured with Sudan reagent. (This reagent dissolves in and colours fats.)

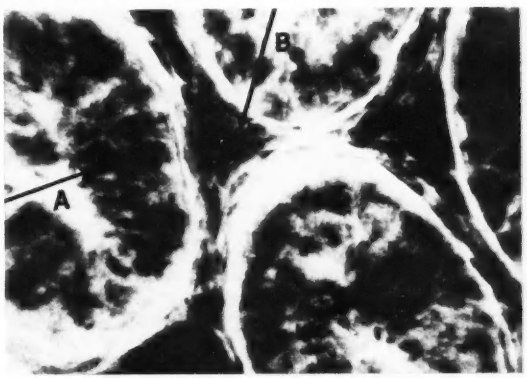


FIG. 3.—Gradually this fat disappears. Arrow A shows last remaining traces in the tubules; B shows the new cells of the 'interstitial gland' gaining rapidly in size and capacity. Sex hormones are liberated; the birds get restless and prepare to migrate.

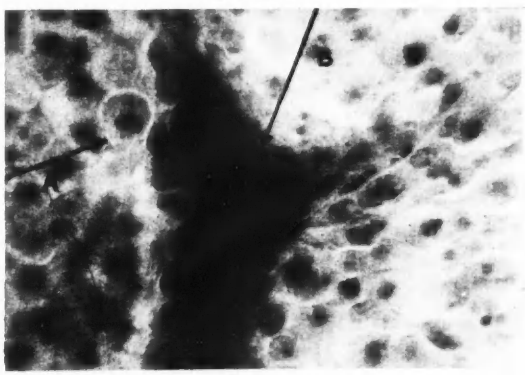


FIG. 4.—By the time many species arrive in England the tubules are active again and the male bird (of many species) is almost ready to breed. Arrow A indicates ripening tubules; B shows enormously enlarged 'interstitial gland'.

that if the reproductive hormones did not cause it, then something else must. As good a guess as anything was that tiny complex little gland, the anterior pituitary, up under the skull. So the already overburdened pituitary (overburdened in the literature at least!) began to be considered primarily responsible; though not perhaps by anybody who had ever looked at it carefully. One American zoologist postulated the existence of a hypothetical 'pituitary clock' that at a given time each year would somehow start the birds off on their flight. This idea, however, has been put thoroughly out of court by Baker of Oxford who calculated that if the so-called 'clock-rhythm 'of a spring-breeding bird of the last glacial epoch varied by as little as six minutes a year the bird would today breed in the autumn. We know enough about the time factor in biological reactions to know that any such idea of an independent rhythm is absurd.

We seem to be back about where we began. However, for the past couple of years, first at Oxford and now at Bart's Medical College, we have been making a detailed study of the biology of the reproductive organs of migratory birds. We had the greatest difficulty in getting birds but we got lots of migratory species in West Africa (during their quiescent period there and just before they left for the north) through the courtesy of the Governor of the Gambia. We made an expedition to the Island of Jan Mayen in the Arctic and got birds that had just finished breeding and were on their way southward again. And now we are getting birds as they pass Great Britain and Eire on their way northward and later while they are *en route* southward again. Most of the birds collected here are got from the bases of lighthouses—St. Catherine's, Isle of Wight for example—after the birds have dashed themselves to death while on their flight. And from Norfolk we get the verminous hooded crow; and get it again when it reaches Scandinavia. These Dr. Coombs and I can study comparatively with the organs of a *stationary* population of hooded crows in Scotland.

By studying the chemistry of the reproductive organs of birds at all stages of their migration, whether the organs are large or small, obviously active or apparently (because small) inactive, and subjecting them to laboratory techniques that have not been used in this kind of study before, we have been able to find some things out.

Now, in the male testes the reproductive tissue is composed primarily of two parts: the tubules, where the spermatozoa are elaborated, and, between the tubules, the interstitial tissue where the sex hormone is manufactured. In this organ we have been able to show the existence of the internal rhythm that some people in the past have felt probably must exist. After the breeding season the tubules that contained the spermatozoa undergo a marked change and are now found to contain massive quantities of fat. This fat in the testes is rather special; it has nothing to do with the fat that migratory birds (and hibernating animals) lay down on various other parts of the body. Then, gradually this fat disappears; and meanwhile the new cells that have been formed in the interstitial gland increase in volume and secrete in turn a special kind of fat in which the sex hormone is apparently elaborated. Now here is the main point. All this is going on while the organ is extremely small and *apparently* inactive. But though it is small it is not inactive—important changes in the tissues are slowly taking place. Then, suddenly, the last of the fat is cleared from the tubules and the interstitial gland soon takes a sudden spurt forward. It is at this time that the birds grow restive, and soon they set off on their long journey to the breeding grounds. The rhythm is started off, and it seems to start the bird off. And by the time they arrive in southern England the tubules are active again and the male birds of many common species are almost ready to breed. The females lag behind a little in development, but they are coming along too.

So we believe that Rowan was right, though he didn't have all the evidence that we have now. But what is it that starts off the change which sets the hormone-manufacturing mechanism in operation? What begins the process at a given time each year? Is it, perhaps, light?

We do not think so. We know that you can stimulate the development of the reproductive organs of all sorts of animals by shining light on them; but you can do the same thing by injecting some copper sulphate into their third ventricle, and surely that would not happen in Nature! We have now established the fact of an internal rhythm and we know that this is kept 'on the rails', by events in the environment somehow or other. In short the sexual cycle is kept under control and so a bird will not suddenly start off for the north and arrive there in the blackness of an Arctic winter. But, actually, *two* alternative means occur: first (as was thought by Rowan), some environmental factor (or factors) starts the rhythm off in Africa and thus starts the bird off. Second: it may be that the rhythm goes on slowly of its own account after the breeding season and jumps itself when a certain developmental threshold is reached: and at that period, year after year, the birds migrate. In the first case the rhythm is kept anchored in time, first by factors in the south; in the second it would be kept anchored in time by the environmental factors that time the breeding in the north in addition to the rate of post-nuptial recrudescence in the organs themselves. Up till recently I have suspected that the former occurs, but, apart from the light experiments, there are no data that are worth much to prove it. We are now working on the second idea.

It would seem that every seasonal animal, whether it be a viper in an English field or a bird of paradise in a New Guinea jungle, has evolved its response to a combination of environmental factors and when the combination is 'just right' mating begins and so the young are born at a time of the year most propitious for their survival. We still do not know what precisely these factors are in *any* single wild animal. We know that in each bird there is an internal rhythm of which we now have *physical* evidence and that when this 'trips over' sex hormones are liberated and are responsible for the migratory movement. When these hormones begin to flow each bird starts off in the fashion of its kind, doing the same thing as its parents, and its parents' parents did, and so on. This has been going on for thousands and thousands of years: the birds that did the 'wrong' thing, so to speak, were ruthlessly weeded out by natural selection and elimination; they did not live to reproduce their kind.

A. J. MARSHALL, B.Sc., D.Phil.

This script is almost identical with the talk as broadcast except for the fact that such words as 'don't' and 'it's' have been written as 'do not' and 'it is'.

Harnessing the Tides: Is it Practicable?

ROLT HAMMOND, A.C.G.I., A.M.I.C.E.

TIDAL power was first used centuries ago, although only on a relatively small scale; in the eleventh century there was a tidal mill in operation at Woodbridge, Suffolk; and in the Domesday Book reference is made to a probable tidal mill near Dover. The early water supply of London was pumped to a water tower by a mill operated by the tidal flow; it consisted of a large paddle wheel mounted on a raft and moored between two of the piers of old London Bridge, and this worked until the old bridge was replaced by the present structure in 1824. In 1790 a tidal basin water-wheel installation was operating on the River Tamar, Devon, the wheels being later replaced by turbines.

The most comprehensive study of the potential tidal power round the coast of England and Wales, so far published, is that by Norman Davey (*Studies in Tidal Power*, Constable, London, 1922), who pointed out that of all the systems suggested for applying tidal power, the most practicable is the basin system. A portion of the sea is enclosed behind a dam or dams, and allowed to run through turbines as the tide falls. The first proposal for a basin scheme is believed to have been put forward by Lucas and Richardiére in 1839, in which it was proposed to employ two basins, one using the inflowing tide and the other the outflowing.

Since the power obtainable from a given height of water, generally called the head, varies as the square of the head, and the latter varies as the tidal range, or difference in level between high and low water, the power available at different sites from tidal energy shows very wide variation. For example, in the Bay of Fundy the difference between high and low water is 50 feet, whereas the corresponding range in the Adriatic, at Zara, is only 6 inches; average tidal range for the world as a whole is 2½ feet. This extreme variability is the crux of the tidal power problem, and it is with the object of surmounting this that the various tidal basin systems have been evolved.

Tides are caused by combined attraction of sun and moon on the waters of the revolving globe, and when sun and moon act in combination we get tides of maximum range, or spring tides. Conversely, when sun and moon act in opposition in the first and third quarters we have neap tides, which provide minimum range. One of the chief difficulties in planning development of tidal power on a practicable basis is that the tidal cycle occupies rather more than fourteen days, with high tide occurring 25 minutes later each tide, or 50 minutes later each day.

The simplest scheme for developing tidal power is the single-basin arrangement, in which a single basin of constant area is provided with inlet sluices large enough to admit the tide with only very small loss of head, the level of the water in the basin being the same as that of the tide outside. At high tide, when the basin is full, the sluices are closed, and as the tide falls the water flows out through the turbines to generate power. A head, or pressure, of water must obviously be provided for the turbines to generate energy, and they will continue to operate until a point after low water at which the falling water-level in the tidal basin coincides with the level of the rising tide.

We therefore have to reconcile three variables in order to generate maximum power, namely: the capacity of the turbines; the minimum head under which these turbines will operate efficiently; and the period of delay in beginning the operation. In the older designs of water turbines, high efficiency was maintained over a relatively small variation of water pressure in the turbine, but modern turbines can be designed to operate at high efficiency over a much wider range of pressure. The Kaplan type of water turbine, indicated in Fig. 1, operates after the manner of a variable pitch propeller as used in ships and aircraft. Between the fully open and the closed positions of the blades, there is a range of angles at which they can be set to give maximum efficiency at definite heads. This type of turbine incorporates a hydro-brake which consists of a number of vanes projecting from the hub of the runner, actuated by the governing mechanism of the turbine and so controlling the speed.

Designs have been prepared by Dr. P. W. Seewer for turbines of 28,500–35,000 horse-power output for the proposed Severn Barrage, to run under an average head of about 25 feet at a speed of 50 revolutions a minute, but also to be capable of operating efficiently under a head variation ranging from a minimum of 7 feet up to a maximum of 47 feet. It has been stated that this type of plant, apart from its large size, would present no great design or operational difficulties. Thus, the propeller-type of turbine is very suitable for tidal power operation, because the head on the turbine is reduced with the falling tide, and the angle of the blades is altered accordingly to obtain maximum efficiency while water is falling.

It is usually considered that a tidal power scheme can be conveniently located in an estuary or creek, because there high tidal range and economical storage can be

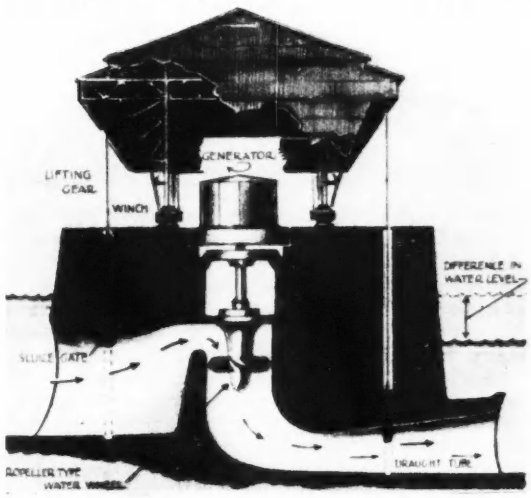


FIG. 1.—The heart of the tidal hydro-electric schemes —the Kaplan turbine which converts water power into electric power.

achieved; in this case, the ebb tide has a longer duration than the flood tide. On ebb-tide working, slower fall of the tide causes the head to build up more slowly than on flood-tide operation. Although power output is reduced, the period of operation is increased. Conversely, on flood-tide operation the more rapid rise of the tide causes the head to build up more quickly and a higher output to be obtained, but the period of operation is reduced.

More generating plant is therefore required, but this will not operate at maximum efficiency, and the advantage of providing larger output with unequal tides will thus be considerably discounted. The chief aim of the designer of a tidal power plant is to achieve as long a period of operation as possible, the turbines beginning and finishing work at the minimum head which will provide maximum efficiency, and this is the great advantage of having turbines equipped with variable-pitch blades.

The great and most obvious problem about tidal power is its intermittent nature, and a single-basin scheme will give an intermittent supply of power varying considerably over the period of operation. Since high tide occurs about 50 minutes later each day, power will be available by this amount later each day, which is a great inconvenience. Tidal range, or the head of water provided by a tide, which is the difference in level between high and low tide, shows wide variation; at spring tides it is nearly twice that at neaps, energy output at springs being nearly three times that at neaps; in the case of the proposed Severn Barrage, this ratio is $3\frac{1}{2}$. It is quite clear that so far, a public power system could not conveniently make use of such a variable

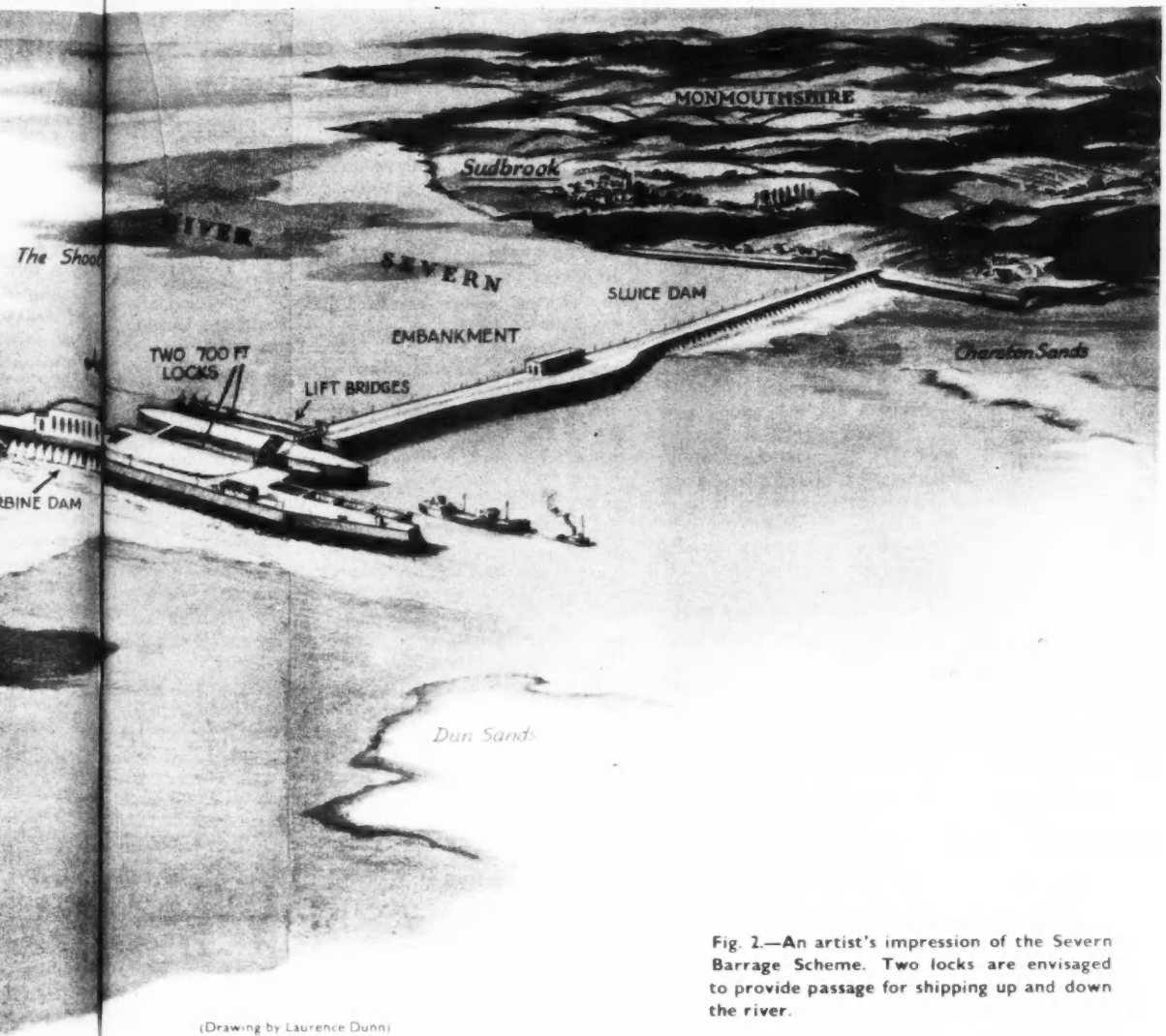


Fig. 2.—An artist's impression of the Severn Barrage Scheme. Two locks are envisaged to provide passage for shipping up and down the river.

(Drawing by Laurence Dunn)

and intermittent supply, and this is perhaps the chief reason why tidal power has not been developed on a large scale.

Much study has therefore been devoted to various methods of regulating output from a tidal power scheme; one is the two-basin system, for example, as suggested for Menai Straits, and as shown in Fig. 3. The sluices of both basins are in direct communication with the tideway; as the tide rises, the upper basin is filled through the inlet sluices. The lower basin, previously emptied on the falling tide, will remain empty; at the turn of the tide, water will pass from the upper basin through the turbines to the lower basin and power will thus be generated. In the double-basin system, constant and continuous output is maintained by suitable adjustment of the turbine valves to suit the head under which the turbines are operating.

Although a two-basin system will regulate power output on an individual tide, it still leaves unsolved the problem of the great difference in output as between spring and neap tides. This system is therefore only a partial solution to the problem of getting a steady output of power from a tidal scheme.

A possible method of regulating output is to combine two or more tidal power schemes, through a high-voltage transmission system from sites which have the necessary difference in the time at which high tide occurs every day, so that they can between them provide a regulated output. It appears to be very difficult to find these desirable conditions, and this scheme again does not solve the difficult problem of the great difference in output as between spring and neap tides.

In many conventional hydro-electric schemes—for example, in Switzerland—pumped storage is used for regulating output, and this system was also considered for the Severn scheme. In this system, any surplus power from the tidal generating station is used to pump water from a low-level reservoir—which would be the sea in this case—to one at high level, water being drawn from the latter to generate power at those times when the tide is not operating, passing out through the turbines to sea level. This method provides complete regulation, but it is much more expensive.

The suggestion has also been made that a tidal power scheme can be combined with a hydro-electric station to give a regulated output, but success will depend on the ability of the hydro-electric station to store enough water so that it can supply power during those periods when the tidal power plant is not working.

This basic principle can be applied, however, where a tidal power station feeds its output into an existing grid system—such as that of the British Electrical Authority, for example—which is served by a group of steam power stations. In this case, whenever tidal power is available, output of the steam stations would be reduced to that extent. This would lead to a saving of fuel and reduced wear and tear on the steam plant, but is open to the objection that the intermittent nature of tidal power output makes it necessary to have steam stations of the same capacity as that of the tidal power plant, and this makes the overall cost of power obtained from such a combined scheme very high.

So far, I have concentrated on the many difficult problems of tidal power development which have to be surmounted, but we must also remind ourselves that this form of power has certain definite advantages. For example, output of a tidal power station can be foretold for a long time ahead, because it is dependent on the height of the tides, and although this may be affected by winds and floods, rise and fall for some sites are given in published tide tables. In those cases the amount of energy that can be produced, and the time at which it will be produced every day, are known in advance.

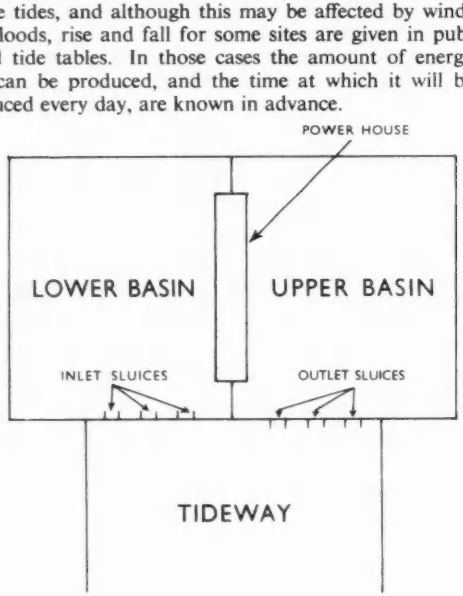


FIG. 3—Diagram of two-basin system.

Tidal power, unlike that produced from oil and coal, is the same as hydro-electrical power in being a non-wasting asset and after the capital cost of a tidal power scheme has been paid off, the cost of power generated is very low indeed.

Let us now consider a few of the most promising tidal-power projects which have been put forward. The first scheme for a Severn Barrage scheme, the most practicable so far examined in Great Britain, was suggested in 1849, and was followed by a further proposal in 1918. Then in 1933 came the Brabazon Report, which concluded that the scheme was practicable. At that time, however, the project was considered, by some persons, to be economically unsound, and it was not until 1943 that the matter was again raised officially, when the Minister of Fuel and Power appointed a panel of three engineers to review the scheme, mainly because of the shortage and rising price of coal.

In 1926 a tidal model was made at Manchester University and a series of experiments were carried out in connection with the proposed Severn Barrage under the direction of Professor A. H. Gibson. The effect of the proposed scheme on such matters as the deposit of silt and the erosion of the shore were carefully studied, and lessons of great value were derived from these experiments. Some of the dock authorities in the Bristol area were still not satisfied with the results of previous model experiments, and in 1947 the Government sanctioned a further tidal model investigation to be carried out by the Hydraulics Research organisation under Sir Claude Inglis.

Some aspects of the Severn Barrage are thus still being investigated. One of the most important points in its favour at the present time is that it would save about a million tons of coal every year if it were built. It has been suggested that the most suitable direct application of the power generated could be for the heating water for large district heating schemes, and that in the case of this Barrage the power could be transmitted at high voltage to centres where such schemes are required. The hot water could be readily stored in large insulated containers. By this method the difficult problem of the intermittent nature of tidal power would be surmounted.

The Severn Barrage is a single-basin scheme (Fig. 2). At the start of operation, which is shown by the sketch, the head on the turbines is about 47 feet, and when the station is closed down the head is only about 7 feet. At this point the tide will be rising in the estuary, and the gates in the sluice dam will be opened when the water-level is the same on both sides; at high tide the sluice gates will be closed, and the cycle will start all over again, beginning 50 minutes later each day. Ship locks are provided so that shipping can pass up and down the river even when the power station is operating, and there will have to be a number of fish passes provided so that fish can also pass up or down the river.

Another interesting tidal power project has been proposed for the Bay of Fundy, New Brunswick. Here the tidal range is the greatest in the world, varying from 21·1 feet on neap tides to 52·2 feet on springs; corresponding figures for the Severn scheme are 22·2 and 47·6 feet. At this site it is proposed to use the double-basin system; the estimated cost of the scheme is $156 million, about a quarter of which would be spent on dredging.

[Continued on p. 361

THE Bay of
a blue sky,
and Capri t
mass of Ve
On the flat
orchards, a
vated. The
hundred litt
coils of sea
wheeling cr
home shore
of animal a
organisms v
of the north
the water is

The city
the bay. It
polis means
of Southern
and noise,
but still an
inhabitants
in a fine pu
well-to-do
here in 187
beach outsi

The Stazione Zoologica, the oldest marine biological station in the world.

Marine Biology at Naples

JOHN CRAMMER

THE Bay of Naples is a wide expanse of blue water under a blue sky, with the mountains of the Sorrento peninsula and Capri to the south, Ischia to the west, and the brooding mass of Vesuvius rising in solitary grandeur on the east. On the flat land and the lower slopes are vineyards and orchards, and everywhere lemon trees and olives are cultivated. The almost tideless Mediterranean washes on a hundred little beaches of volcanic sand; there are no great coils of seaweed on the rocks and jutting cliffs, and no wheeling crying gulls such as the northerner meets on his home shores. The Mediterranean is rich not in quantity of animal and plant life but in variety of species, though organisms which breed once annually in the cool dim seas of the north reproduce several times more often here where the water is warm and the sunlight intense.

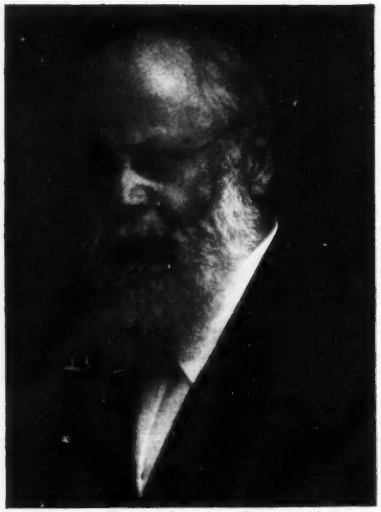
The city of Naples sprawls along the northern shore of the bay. It was an ancient foundation of the Greeks (*nea polis* means new city) and for several centuries the capital of Southern Italy; today it is full of seething jostling life and noise, and the most indescribable poverty and decay, but still an important international port with a million inhabitants. The Stazione Zoologica is set close to the sea in a fine public park, the Villa Nazionale, in the relatively well-to-do suburb of Chiaia. When Anton Dohrn came here in 1870 to start building it was an unkempt deserted beach outside the city; now Naples has spread far west beyond it to Posillipo and Bagnoli, and trams and trolley-buses speed past every few minutes.

For seventy-six years this, the first great marine biological station in the world, has been building up and sustaining an extremely distinguished reputation for the quality and importance of its pure research. Unlike other marine laboratories it has no concern for fisheries research or any purely practical applied study. Unlike other stations it has no allegiance to a government or a university, but is independent and autonomous. It is probably the most international scientific institute in the world. It was built by a German in Italy with funds from several European countries, and today is still in part maintained by international subscriptions, the famous 'Table' system. In this various governments and scientific societies pay annually towards the upkeep of a work table, to which they have the right to nominate a scientist who can study there. Thus in 1949 thirty tables were paid for—one each by the governments of Austria, Belgium, and Switzerland, eight by the Italian Ministry of Education, six by the National Research Council in Rome, three by the province and one by the city of Naples, one each by scientific societies in Holland, Sweden, and the United States, four by British organisations (Oxford and Cambridge universities, University College London, and the British Association), and two by Unesco.

From the very beginning it has attracted an international galaxy of young workers, who have in time returned to the leadership of research in their own institutes and universities and to watch over the continued flow of students and funds to Naples. Today, when even the scientific world is splitting under political tension, it is refreshing to find an institution which has gone quietly on with its international work for three-quarters of a century without any of the paraphernalia of representative committees and consultative conferences so often found necessary.

The Institute came into being against strong official opposition, largely through the peculiar genius of one man, and his story is worthy of a brief telling.

Anton Dohrn was born at Stettin on the Baltic on December 29, 1840, the son of a wealthy man of wide culture who was a keen musician, translated dramas from the Spanish, travelled widely—especially in Italy, and was an enthusiastic entomologist. Anton grew up to share most of these activities, and duly studied zoology as a university student, though without any great enthusiasm. He was about to become a bookseller when he chanced to read Charles Darwin's *The Origin of Species*, then a recent book (published in England in 1858), and his whole outlook was at once changed. It was an era of marine scientific explorations, by H.M.S. *Beagle*, H.M.S. *Rattlesnake*, and later the *Challenger* expeditions, and this helped to turn his mind to the biology of the sea, when he had once been fired with enthusiasm by Darwin's evolutionary ideas. While others sought for detailed evidence of evolutionary history in the study of fossils or of comparative anatomy, Dohrn chose the development of the individual from egg to adult, which recapitulated in a measure the evolution of the species, as the most reliable guide to biological origins; and for the greater part of his scientific career he was to search in the sea for the origin of the Vertebrates. For a time he came to work in Britain, first meeting Darwin and then staying at Millport to work in the private Clydeside laboratory of a Mr. Robertson. He returned to Germany to study under Haeckel and Gegenbaur and took his doctorate at Jena in 1868. It was while travelling in a stage-coach near there on January 4, 1870, when he was 29 years old, that "like a revelation"—to use his own words—the idea which was to be his great life achievement suddenly came to him.



Anton Dohrn, founder of the marine biological station.

For some time he had felt the need of a laboratory near the sea, where its fauna and flora could be studied on dry land yet in the living state and without any of the difficulties of long and awkward journeys. The sea had cradled life, and the transmutation of species, which seemed to him a physiological problem, could best be studied in it. For some time, too, there had been public aquaria in Berlin, Hamburg, and London, run as commercial peep-shows. Suddenly it struck him to combine the two, aquarium and laboratory: the peepshow could finance the research. This could only work in a large seaside town with plenty of visitors and a vast marine life within easy reach, and having resolved to make his idea a reality he looked round for the best site. At first he tried Messina in Sicily, where the deep waters of eastern and western Mediterranean meet to wash to and fro in the shallow straits. Then he moved to Naples, and here in March 1870, as he himself subsequently related, "without a guide, with wholly inadequate means, entirely lacking in business experience, in a foreign country of whose language I was all but ignorant, I signed an agreement with the administration of one of the most difficult cities to handle in all Italy".

The experts in Berlin regarded Dohrn's scheme as fantastic and doomed to failure; his father refused to help him; and the Naples city council soon regretted their agreement and became obstructive. For four years he had a constant struggle to raise funds and to retain his building permit. He was continually travelling backwards and forwards, attending innumerable meetings to win supporters, writing popular articles, calling on influential people and exercising all his dialectic eloquence and charm. A committee of British men of science, including Darwin, T. H. Huxley, Lyell, and Sir John Lubbock, sent him £1000 at a time when the pound sterling really meant something. He interviewed the Berlin men of science one by one, beginning with Du Bois Reymond, and won them round individually: one remarked afterwards that if Dohrn attacked the fauna of Naples with the same resource there would be nothing left to investigate in five years. Eventually the breach with his father was healed, and with the support of letters from Darwin and K. von Baer, he obtained the family fortune to use towards the cost of building. In Naples, the council twice ordered the building to stop, on the grounds that features of the originally agreed design had been altered; and public opinion demanded that the whole thing be demolished. After many personal struggles Dohrn succeeded in winning over the Barone Savarese, majority leader in the city council, and from then on he was secure.

Finally, in February 1874, after many vicissitudes, the Station was complete. The original building still stands today as a central block between the two large wings subsequently added when the laboratory's work and success had grown, and though the flat Dohrn originally occupied is now part of the library the colourful and interesting frescoes painted by Hans von Marées still remain. Anton Dohrn died in 1909 and was succeeded by his son Reinhard as owner and director. Then came the 1914–18 war, which made it impossible for a German to hold property in Italy. Since then the Station has become a trust, with Professor Reinhard Dohrn continuing as

director, latterly assisted by his son Peter. The income derived from the aquarium has fallen off during the wars, including the Italo-Abyssinian war of 1933, and necessitated greater international support, but otherwise the laboratory has come through unharmed.

From its very early days the laboratory began to publish an annual review of zoological literature (the *Zoologischer Jahresbericht*) which indirectly helped to build up what is now a very fine library of books and periodicals. It also began a long series of monographs on the *Fauna und Flora des Golfes von Neapel*, systematic surveys which still appear from time to time, and which are essential to the research it fosters.

Its permanent full-time staff is small—no more than six all told at present, and its research programme is therefore greatly influenced by the needs of visiting workers. Dr. Bacci, the head of the zoology department, who has recently returned from a year's work at the Marine Biological Laboratory, Plymouth, has developed the culture of marine worms in the laboratory. These worms breed every two months throughout the year, and should therefore be very useful for genetical research (which has hitherto concentrated on the rapidly breeding fruit-fly, *Drosophila*, and the easily cultivated mould *Neurospora*), as well as for work on sex determination, a subject which Dr. Max Hartmann of the Kaiser Wilhelm Institut für Biologie now at Hechingen comes regularly to Naples to study.

Dr. Antonie Dohrn himself has been collaborating with Professor Rein of Göttingen on physiological studies of the shark *Scyllium*. They have found that this fish can be kept more or less permanently anaesthetised with a barbiturate, so that it remains motionless, balanced, and still respiring and suitable for experimentation. They are interested in a hormone liberated by the spleen under conditions of stress (lack of oxygen in particular), which stimulates the heart and liver, and which may be responsible in man for the well-known phenomenon of 'second wind' during exercise.

A group under Professor Runnström of the Wenner Grens Institute in Stockholm has for some years been coming to study the physics and chemistry of the fertilisation of the ovum by the sperm, especially in the sea-urchin which produces convenient material for experiments. As a direct result the Station is now well equipped for modern biochemical work, especially on proteins. It has a freeze-drier, a large cooled centrifuge, a Geiger counter for radio-isotope work, Beckmann spectrophotometer, Warburg manometers, and of course much orthodox physiological, physical and chemical apparatus, and a staff of technical assistants to help with special requirements, such as the building of thermostatically cooled or heated aquaria. The usual laboratory services include circulating sea-water pumped from a basement tank to all research rooms. A mile away at the small harbour of Mergellina, the Station maintains three vessels, the largest a 12-metre motor-boat. Six fishermen go out every day to collect material as required. The Station does a thriving business in specimens, both living and preserved, which it supplies to schools, universities and museums.

It is impossible to describe all the investigations in progress. The 1949 report lists nearly ninety research topics.

Visitors vary in the time they stay; it may be as little as a fortnight or as much as a year. Their numbers are slowly getting back to normal after the recent war. There were 57 of them in 1947, 65 in 1948, and 75 in 1949. The detailed analysis of the last figure shows one each from Austria, Brazil, France and Norway, four each from Holland and Switzerland, five from Sweden, eight from Germany, ten from England, and 39 from Italy. Though work is possible all the year round the fauna is at its best in February and March, while the heat in July and August makes research somewhat uncomfortable if not difficult.

Although it is called a Zoological Station there is a warm welcome also for botanists, though they have not hitherto taken much advantage of the facilities offered for the study of marine botany. Indeed anyone seriously interested in science of some kind and likely to benefit by the laboratory's help may apply for admission and in some cases financial aid towards the cost of research. Archaeology and underwater photography have both received support on occasion, and there are two Unesco fellowships reserved for non-European workers. A welcome is extended also to those outside the usual academic run, provided they can demonstrate their genuine need for encouragement or assistance. This broad policy is, of course, one of the fruits of the Station's autonomy.

HARNESSING THE TIDES: IS IT PRACTICABLE?—*continued from p. 358*

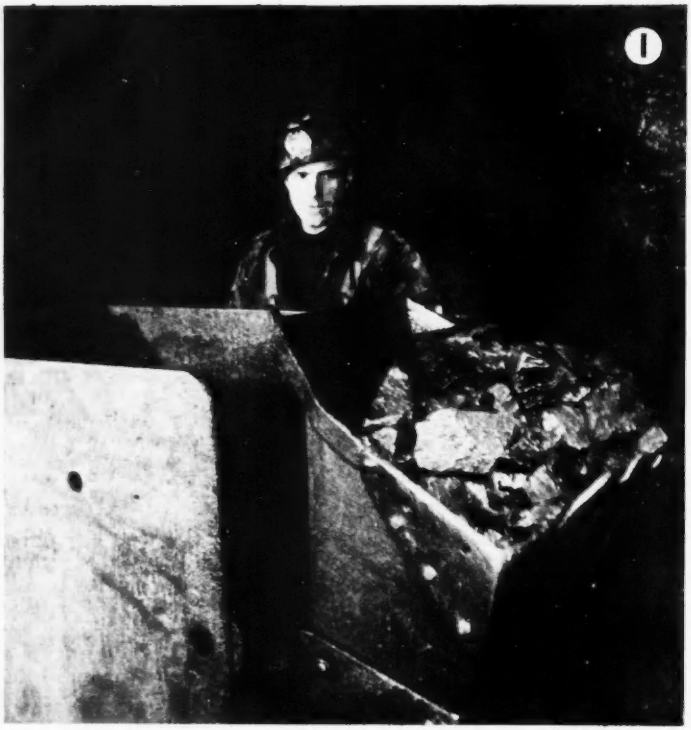
Work on a tidal power scheme at Passamaquoddy on the coast of Maine, U.S.A., was begun in 1935, but was suspended in the following year; the tidal range on this site is 11 feet on neaps and 26 feet on springs. A report by the U.S. Federal Power Commission, published in 1941, reached the conclusion that it could not at present compete with ordinary hydro-electric projects, or even with large modern steam plants.

French engineers have also shown great interest in the possible development of tidal power off their coasts, and in 1941 a body of enthusiasts formed a Society for the Study of Tidal Power. The Rance scheme, in the long estuary which culminates opposite Dinard and St. Malo, appears to be the most promising, having a tidal range of 10·8 feet at neaps and 37·9 feet at springs, the estimated output of energy being 700 million kilowatt-hours per annum.

With the growing scarcity and rising price of coal, and with the increasing use of coal as a raw material for the chemical industry, it might be expected that every means would be eagerly sought by engineers and scientists to develop all latent sources of power in Nature. Both tidal and hydro-electric power could become increasingly important in the national economy if these methods are given the attention they deserve.

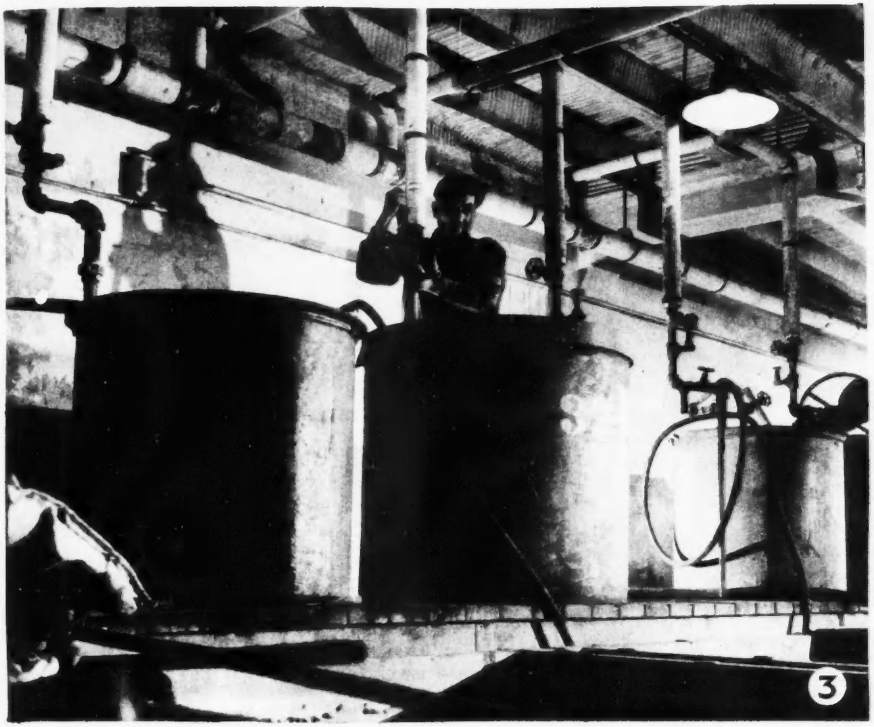
The Refining of Radium

There is much talk of possible substitutes for radium, but it is likely to be a long time before any of the artificial radioactive isotopes come to replace radium so far as its major uses are concerned. The radium of medicine and industry is derived from pitchblende, a heavy and radioactive mineral with a pitch-like lustre and consisting largely of uranium oxides. The proportion of radium in pitchblende is minute; only a fraction of an ounce of radium can be extracted from many tons of pitchblende.



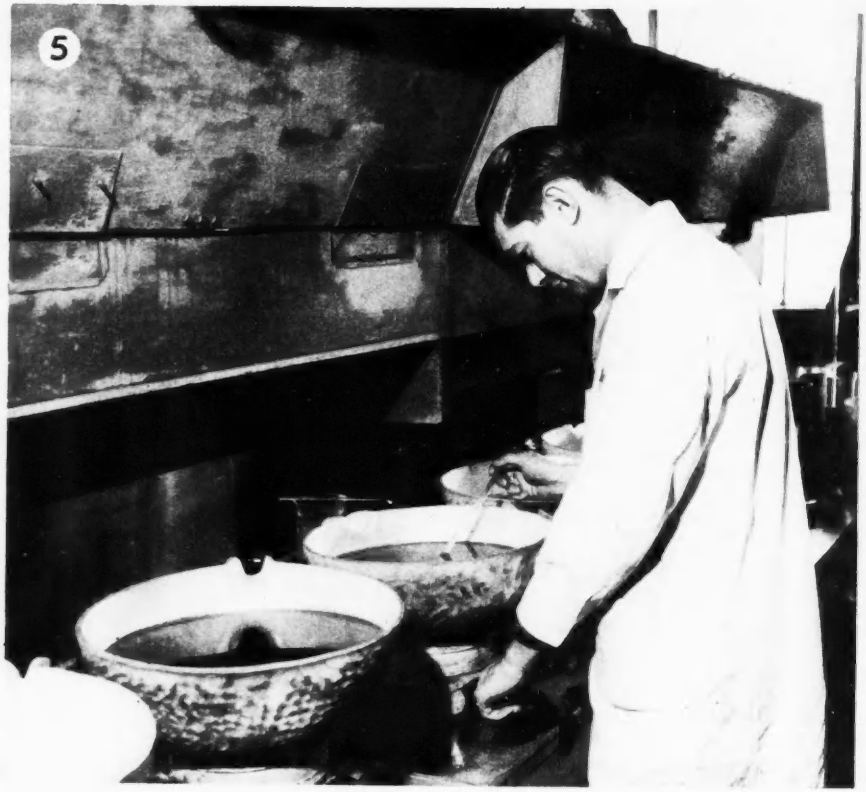
1. The pitchblende from which the Curies first isolated radium came from the famous Joachimsthal deposits in Czechoslovakia, which is to-day being exploited for its uranium content. The richest pitchblende deposit is the Katanga deposit in the Belgian Congo. Also of great importance is the Eldorado mine on the Great Bear Lake, where this picture was taken; here the mineral occurs as solid bands occasionally a foot in width, but more commonly in lenses a few inches wide.

2. Although half a century has elapsed since the Curies discovered radium in 1898 the process for obtaining it on a commercial scale is essentially the same as the discoverers used. The ore is concentrated at the mine. The oxides which go to make up the pitchblende are then converted into carbonates, which are here being dumped into large tanks of acid.



3. The carbonates are dissolved in hydrochloric acid. The solution is siphoned into large vats and filtered to remove insoluble impurities.

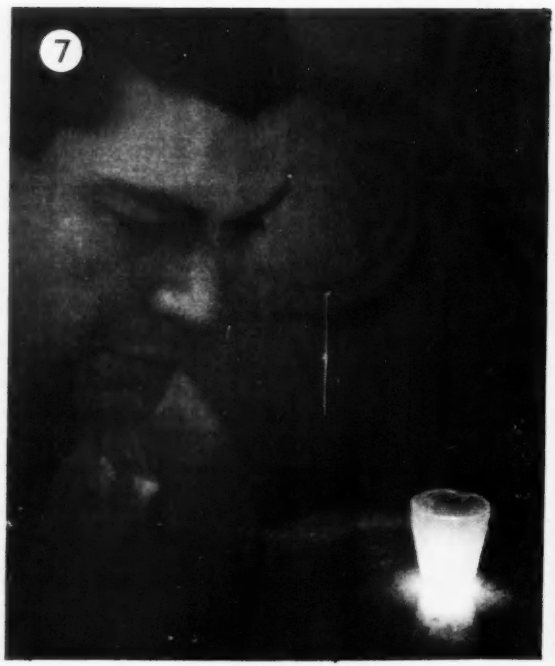
4. The solution is concentrated by evaporation. Then begins the process of fractional crystallisation, whereby the radium salt is separated from the salts of other metals.



5. From the original tons of pitchblende we are now down to a small quantity of radium salt solution.

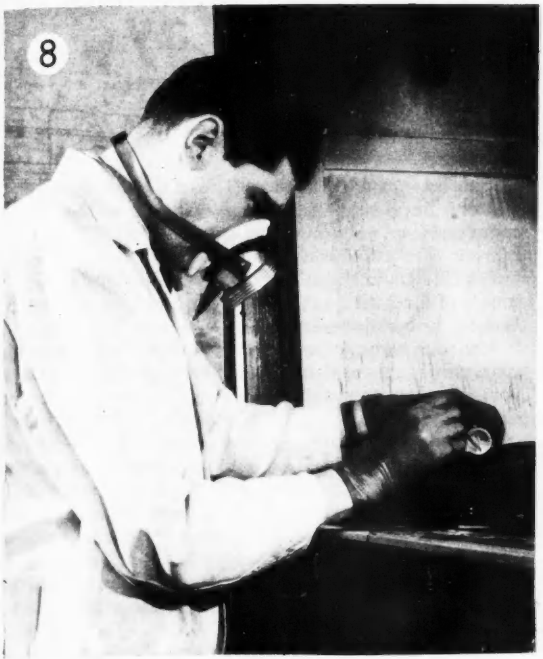
6. The radium solution is now so concentrated that radiation hazards are encountered, and further processing has to be done in a lead-shielded laboratory.

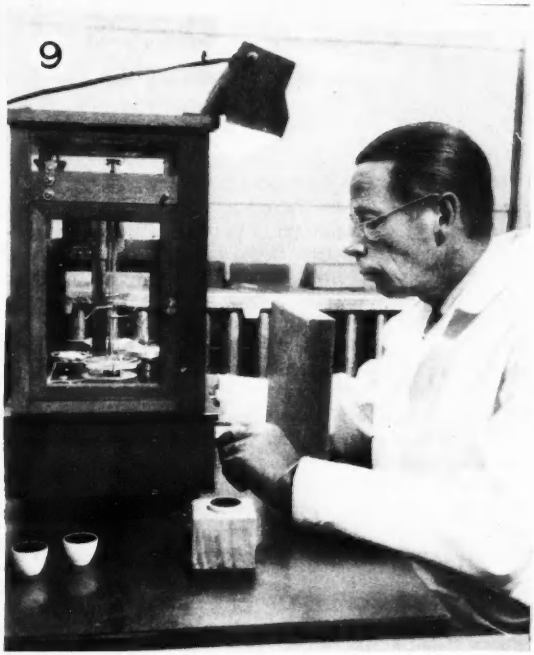
7. The end product of refining—pure radium salt, which glows with a pale blue light.



8. Radium
rapidly, to
radium sal

9. The rad





8. Radium, the metal, is too unstable, because it oxidises extremely rapidly, to be used. What is commonly called 'pure radium' is a radium salt, in this case radium bromide. Here radium bromide is being sealed into glass tubes.

9. The radium salt is being weighed on a precision balance behind a lead shield.

10. Radium bromide has the disadvantage that it is deliquescent. For easier handling it is often converted into radium sulphate which is insoluble.

11. Here, in a glass-enclosed and lead shield case, the radium sulphate is being packed into the conventional 'needles'. Each needle is about the same size in diameter as the 'lead' in a lead pencil.

How Bees find their Way

C. G. BUTLER, M.A., Ph.D.

It has for very many years been the opinion of some bee-keepers and others who have studied bee behaviour that honeybees possess the power to transmit information from one individual to another. It was not until 1923, however, when Professor K. von Frisch published his famous paper on the dance 'language' of the honeybee, that it was definitely established that the worker bees of a colony are able to communicate a certain amount of information to each other. Only during the last four or five years have we begun to realise just how precise such information can be.

Very briefly, von Frisch in his 1923 paper was able to show that when a foraging honeybee discovers a rich source of nectar or pollen she will, on returning to her hive, frequently perform a little dance on one of the combs and that some of the neighbouring bees that become interested in her dance and follow her round eventually leave the hive independently and subsequently appear at the source of food that the dancing bee has discovered. At this time von Frisch recognised two more or less distinct dances: a 'round' dance in which the performer runs round in a circle in one direction once or twice and then reverses and runs round the opposite way (Fig. 1); and a 'wagtail' dance in which the dancer traces out a figure-of-eight pattern in which the two loops of the eight are separated from one another by a longer or shorter straight run during the making of which the performer wags her body violently from side to side (Fig. 2). He suggested that by means of the round dance the successful forager is able to inform her sisters of the presence of nectar in the field and that by means of the wagtail dance similar information about pollen is given. The bees that become interested in the dancer's activities learn from her of any floral perfume associated with such food, which perfume they subsequently seek in the field and thus eventually discover the floral source. It was believed at this time that these informed bees search for the perfume in all directions around the hive.

Further work published by von Frisch showed that the round and wagtail dances are but the two extremes of a series of dances and that either may be used to indicate the presence in the field of a source of either nectar or pollen. All the dances of this series may in fact be regarded as having a figure-of-eight pattern, but in the case of the round dance the two loops of the eight are more or less closely superimposed upon one another, whereas in the wagtail dance they are separated by the straight wagtail run.

Von Frisch further showed that when the source of food is situated at a distance of approximately one hundred yards or less from the hive a round type of dance is performed, whereas when the source is more than one hundred yards away a wagtail dance takes its place, and as the distance between hive and food increases the number of complete figures-of-eight completed per unit time becomes progressively reduced. Actually the dancing bee is not indicating the distance as such but rather the amount of energy which she had to expend in flying on her outward journey between hive and crop. Thus if she flies out against a strong head-wind the number of figures in her dance completed per unit time is less than it would be in a calm or with a following wind. Clearly this is of greater biological significance to the bees that are learning about the source of food than any indication of the precise distance between hive and food would be.

Although a worker honeybee may sometimes forage on a crop growing more than three miles away from her hive, von Frisch has found that such a bee does not perform a dance on returning to her hive, and thus does not recruit further bees to work on this crop, however rich the source of food may be. Here again this fact is of biological significance since it has been shown that it is not an economic proposition for bees to work on a crop, even under the most favourable weather conditions, when that crop is more than three miles from home. Such 'distance' indication is accurate to within about 100 yards of the objective at the greater distances and even more accurate at the shorter distances.

In a paper published in 1946 von Frisch also showed that the dancing honeybee is able to indicate the direction in which the food lies relative to the position of the hive and the sun (Fig. 3). If the food lies in the same direction as that from which the sun is shining at the time, she makes the straight run of her wagtail dance vertically upwards on the vertical comb face; if the food lies in the opposite direction to that from which the sun is shining at the time, she makes her run vertically downwards; if the food source lies at an angle to the left of the sun she makes her run at the same angle to the left of the perpendicular and so on. In fact in her dance in the dark interior of her hive gravity takes the place of the sun.

Now if whilst a bee is performing a wagtail dance on the face of a comb this comb is removed from the hive into the light in the open air and turned from the vertical plane into the horizontal with the face of the comb on which the bee is dancing uppermost, the dancer, if she is not too disturbed by this manipulation of the comb, alters the direction of the straight run of her dance until it is pointing directly towards the source of food. She is in fact, now that she is in the light, orientating her dance to show directly the direction in which the source of food lies in relation to the position of the the sun. Dancing under the open sky, she no longer requires to use the direction of the force of gravity to indicate the direction from which the sun is shining at the time.

By throwing a strong beam of light on to a bee dancing on a horizontal comb face in the open air it can be demonstrated that she is orientating her dance in relation to the position of the sun. If the beam of light is projected on to her from different angles she reorientates her dance to this light which to her is clearly now taking the place of the sun. If, instead of turning the comb from the vertical into the horizontal place with the face of the comb on which the bee is dancing uppermost, we turn the comb into the horizontal plane with the comb face on which the bee is dancing

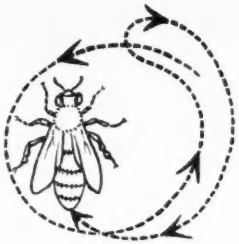


FIG. 1.—A bee is able to communicate to other bees where food is to be found by 'dance language'. This is the pattern she dances when the source of food is relatively near to the hive—the so-called Round Dance of von Frisch. (Figs. 1 and 2 come from von Frisch's paper in *Experientia*.)

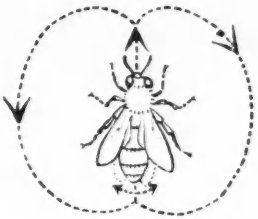


FIG. 2.—As the distance increases, the dance pattern gradually changes until this pattern is reached. Here, in the so-called Wagtail Dance, the bee makes a half-circle to the right, then a straight run during which she waggles her abdomen, and then a half-circle to the left.

facing the ground she immediately becomes completely disorientated and ceases to dance altogether.

If we take a comb on which a bee is dancing from the hive in the open air and keep it in the vertical plane, it can be demonstrated that the bee attempts to orientate her dance both directly to the sun and simultaneously to gravity, with the result that an error is introduced in her indication of direction. The size of this error varies, as one might expect, according to the height of the sun. If the sun is directly overhead the error is slight, as orientation both by the sun and by gravity result in the bee following the same path, whereas if the sun is low down near the horizon, and gravity and the sun are competing with one another in their influence on the bee, the degree of error is considerable.

One of the most interesting of von Frisch's discoveries is that a bee dancing on the horizontal surface of a comb under the open sky does not need to see the sun in order to orientate the straight run of her dance correctly. Indeed experiment has shown that she only needs to be able to see a small segment of blue sky. If her view of the blue sky is veiled by cloud which becomes increasingly dense she dances with less and less certainty until eventually she is no longer able to orientate herself and ceases to dance.

In an attempt to explain how a bee dancing on a horizontal surface under the open sky is able to orientate her dance correctly relative to the position of the sun even though she is unable to see it, and may indeed only be able to see a small segment of the sky, von Frisch has put forward the interesting hypothesis that the compound eye of the honeybee is sensitive to the plane, and possibly also to the degree, of polarisation of the light reflected from a blue or lightly clouded sky, and is thus able to determine the position of the sun even though it is hidden from her view.

Let us examine this important theory more closely. It is a well-known fact that the light that is reflected from certain parts of a blue sky is partially polarised, that is to say, the light waves instead of vibrating in all planes simultaneously vibrate for the most part in a single plane. It is also known that such polarisation of the light is most complete in that part of the sky at an angle of about 90° from the sun, whereas the light that is reflected from the part of the sky immediately around the sun is unpolarised and vibrates in all planes simultaneously. Between these two extremes the degree of polarisation varies in a more or less regular manner. The different planes and degrees of polarisation of the light can be observed by viewing different parts of a blue sky through a polarising filter—that is a filter through which only light that is polarised in the same plane as the filter can pass—such as a piece of 'Polaroid' as fitted in many anti-glare spectacles today.

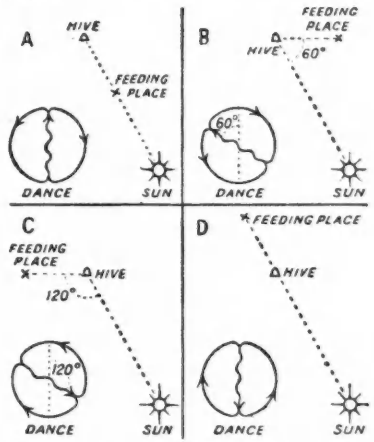


FIG. 3.—How a bee conveys to other bees the direction in which a profitable feeding-place lies with respect to the hive. In *A* the straight run (shown by wavy line in the diagrams, since the bee is waggling her abdomen) is vertically upwards on the comb when the food source lies in the direction of the sun; if the food is in the opposite direction (see *D*), the straight run is vertically downwards. By varying the angle of the straight run to the vertical, the bee can communicate the intermediate directions. (*Reproduced by courtesy of the editor of* The Observer.)

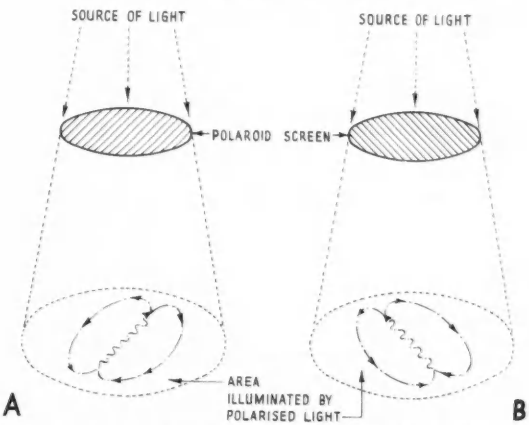


FIG. 4.—Diagram showing the effect of placing a 'Polaroid' screen over the 'window' to the sky of a bee that is dancing on a horizontal surface. Direction of lines on screen indicates direction of polarisation of light. (*A*) wagtail run of dance in same direction as direction of polarisation of light that has passed through the 'Polaroid' screen; (*B*) the screen has been rotated through 90° and wagtail run of dancing bee is reorientated through 90° also.

It is fairly obvious that if, as von Frisch suggests in his theory, a bee can determine the plane of polarisation, and possibly also the degree of polarisation, of the light that is being reflected from a number of different points in the sky which are visible to her, she will be able to judge the position of the sun even though she cannot see it. She would indeed possess something akin to a map in the sky by means of which to orientate herself. Such a theory, if true, could explain why bees stop dancing when the sky becomes covered with fairly dense cloud and the reflected light is no longer polarised.

In 1949 in *Experientia* von Frisch published experimental evidence that he had obtained in support of his theory. He has shown that when a polarising filter, such as a piece of 'Polaroid' is placed between the sky and a bee that is dancing on a horizontal surface in such a way that she can only see the sky through the filter, and is slowly rotated, the bee alters the straight run of her wagtail dance in the same direction and to the same extent as that through which the filter has been turned from the zero point (Fig. 4). If the filter is turned too fast or too far, however, the bee becomes disturbed and ceases to dance.

In the same paper von Frisch suggested that this method of orientation to polarised light from the sky would be found to occur in other insects as well as the honeybee, and he suggested that certain observations on the homing of ants published by Santschi in 1923 could be explained in this way.

During the late summer of 1949 Santschi's experiments were repeated and extended by D. M. Vowles at Oxford working with the ant *Myrmica laevinodis* and the sensitivity of workers of this species of ant to the plane of polarisation of light and their ability to orientate themselves by means of this sensitivity was demonstrated.

At present one is inclined to regard von Frisch's 'polarisation theory' as a working hypothesis in support of which some data has already been collected both in respect to the honeybee and one or two species of ants. In a year or two it is probable that considerably more data will have been collected and we shall then be in a better position to judge the truth or otherwise of von Frisch's theory and also perhaps the extent to which, if it exists, this polarisation sensitivity of the honeybee is useful to her in the field.

It will also be of very great interest to determine whether the eys of insects generally are capable of appreciating the plane of polarisation of light and, if so, whether insects make use of this ability in finding their way about in the field.

So far nothing appears to be known of the mechanism of this probable property of the compound eye of the honeybee, although it is understood that in a very recent paper in *Experientia* von Frisch has brought forward a theory, and some data in support of it, to explain how the compound eye can function in this way. One will await with great interest the publication by von Frisch of the results of his further work on this fascinating subject.

READING LIST

Frisch, K. von. "Uber die 'Sprache' der Bienen", *Zool. Jahrb. Physiol.* Abt. **40**, 1–186, 1923; "Die Tanze der Bienen", *Osterreichische Zool. Zeits*, **1**, 1–48, 1946; "Die 'Sprache' der Biene und ihre Nutzanwendung in der Landwirtschaft", *Experientia*, **2**, 1–21, 1946; "Die Polarisation des Himmelslichtes als orientierender Faktor bie den Tanzen der Bienen", *Experientia*, **5**, 142–148, 1949.

Santschi, F. *Mem. Soc. Vaud. Sci. Nat.*, 137, 1923.

Blue Suns and Blue Moons

On September 26 many people in Britain noticed that the sun appeared to have a blue tint, and on the same night the moon appeared to be blue. We have heard the expression "Once in a blue moon" used to denote some rare occurrence, and the expression is not meaningless because a blue moon is actually seen on certain occasions, though in this country it is not very common. A brief explanation of the phenomenon is given below.

When light from celestial bodies enters the atmosphere, the shorter wave-lengths—the blue colours—are scattered and give the effect of blueness—the most familiar example being the blueness of the sunlit sky. This scattering can be effected by myriads of small dust particles and molecules of gas or water vapour in the atmosphere. The particles causing the scattering vary in size, and therefore certain ranges of the spectrum are filtered out, allowing the remaining parts of the spectrum to produce beautiful effects. Volcanic activity is responsible for dust particles of different sizes and at different heights in the atmosphere, and wonderful effects followed the Krakatoa eruption in 1883; forest fires can produce the same results, and such fires in North America were probably the cause of the recent blue sun and moon. The thickness of the layer of dust and also the dimensions of the particles determine the colour of the transmitted light, and it happened on September 26 that these particles were just the correct size to cause the bluish colour. There is some evidence that the haze of particles was fairly high—between six and seven miles—and it probably drifted over this country from a long distance. The phenomenon occurs more frequently in countries where dust storms occur, but there is always the possibility that some of the dust will be carried over other places by atmospheric movements.

Many simple experiments can be devised to show the effect of looking through a haze of fine particles. One of the simplest is to breathe on a piece of glass and then look at the bulb of the electric light with one eye close to the glass, preferably on the side on which you have *not* breathed. After a few seconds, depending on the temperature of the room, evaporation of the moisture will allow the favourable conditions for seeing the illuminated bulb blue. It may be necessary to repeat the experiment a few times to obtain the best results. When the evaporation is complete the bulb resumes its normal colour.

Far and Near

Radio Bromwich

THE holding of the 17th National Radio Exhibition at Castle Bromwich prevented the use of the euphonious word 'Radiolympia' in the advertising, and indeed it is doubtful whether Olympia will ever again be the site of the Exhibition. It is planned next year to hold it at Earls Court and in 1952 in the provinces.

The Exhibition Hall at Castle Bromwich was only partly filled by stands, and several well-known manufacturers were missing from the list of exhibitors. Nevertheless the Exhibition exceeded the expectations of the Radio Industry Council in the attendance (over 110,000), and attracted dealers from all over the country.

The main items of interest were the B.B.C. Television Studio, specially erected for the Exhibition at a cost of £10,000, the Hall of Television in which 85 receivers were shown working, the Air Ministry's radar trainer, a mobile laboratory for measuring signal strengths, and the new long-playing gramophone records.

The growing popularity of large-screen television pictures was shown by the number of firms demonstrating receivers of this type. A picture 19 ins. by 13¼ ins. is obtainable from the Philips projection receiver, which uses a 2½-in. cathode ray tube operating at 25 kilovolts. Projection receivers were also shown by R. G. D., Decca, Dynatron, Ferranti, and others. One of the most expensive receivers shown combined projection television with radio and gramophone reproduction and was priced at £574.

Departures from the standard practice were noted in the receivers which provided alternative tuning for the Midlands or London programmes, and many receivers were fitted with darkened screens to improve the viewing in daylight. In general, the direct-viewing screen of 12 in. or 15 in. diameter appeared to be the most popular, and there was a marked reduction in the number of visible controls fitted to the receivers.

The Decca Record Company showed for the first time a range of long-playing records and record players made in this country. In order to accommodate both the standard 78 revolutions-per-minute records and the new 33⅓ r.p.m. long-playing records, dual-speed turn-tables have been designed and pick-ups with special interchangeable heads. The diameter of needle tip required for the slow-speed records is 0·0015 in., and that for the normal record 0·0025 in., and permanent sapphire needles of this size are fitted in the two interchangeable heads. The recording characteristic of the long-playing record differs appreciably from that of the normal, and an additional compensating circuit is required in the amplifier. A feature of the new records is the almost complete absence of needle scratch, due to the material of which the record is made, and the upper frequencies are well reproduced. At present the cost is a heavy item and it is probable that the complete recordings of operas will be more popular than the collections of shorter musical items which could be accommodated on a normal 12-in. disc. The "Mikado" for instance, is recorded on four sides of two long-playing discs in its entirety.

A rival to the 33⅓ r.p.m. record is the 45 r.p.m. of the Radio Corporation of America, which requires a special spindle on the turntable for record-changing. This is not yet available in this country, although one motor manufacturer is anticipating the possible introduction by providing a three-speed record player with interchangeable spindles. The unfortunate gramophone lover will soon have to go through an elaborate ritual before enjoying music, or he will find that he is playing a slow-speed record at twice its normal pitch with the wrong pick-up.

America's Sixth Atomic Pile

AT Brookhaven, Long Island, 75 miles from New York City, three years of work has been culminated by the beginning of operations of an atomic pile specially designed to stimulate non-military research.

The pile—the biggest atomic research reactor ever built in the United States—produced its first controlled chain reaction at the end of this summer and is expected to be kept in operation around the clock. The reactor is the sixth such plant in the country. This includes plants designed primarily for the production of material for atomic weapons.

The new reactor and its adjoining laboratories and control facilities are housed in the Brookhaven National Laboratory of the U.S. Atomic Energy Commission.

One of the unique features of the project is a small research hospital for testing the use of short-lived radioactive elements produced in the atomic pile. Some of these elements, in contrast to other radioactive elements made available by the Atomic Commission to research workers in the United States and abroad, have an activity lasting only a few minutes and must be used on the spot. They will be tested against cancer and other diseases.

Snail-killing Chemicals

PROMISING results with several chemicals that kill snails, which act as hosts to parasitic worms causing tropical diseases, are reported by the U.S. Public Health Service. Field studies indicate that these compounds are far more effective than copper sulphate commonly used in this connexion.

Six compounds—pentabromophenol, copper pentachlorophenate, sodium pentachlorophenate, 2,4,6-tribromophenol, 2,4,6-triiodophenol and its sodium salt—successfully killed 90% to 100% of all snails in the area treated. (Test areas included swamps, ponds, streams and drainage ditches containing stagnant water).

Experts conducting the investigation considered two of these—sodium pentachlorophenate and copper pentachlorophenate—to be the most promising for large-scale use. They killed off most of the snail population within a few hours; embryos within the snail eggs were also killed. Their initial toxicity to certain fish and other aquatic life in treated waters disappear within a few days. The only chemical tested that seems to have little, or no effect on fish is 2,4,6-tri-iodophenol but the cost of this iodine compound is too high.

New Chief of Navy's Scientific Service

THE successor to SIR FREDERICK BRUNDRETT as chief of the Royal Naval Scientific Service has been announced. He is MR. W. R. J. COOK. Details of his career are given in the September issue of *State Service*. In 1927 Mr. Cook joined the Research Department, Woolwich, and in 1939 was transferred to the Ministry of Supply Projectile Development Establishment. In 1940 he was appointed to the Ministry of Supply headquarters as an assistant director in the Directorate of Projectile Development, and was responsible for the assessment and planning of rocket requirements and research. In 1943 he returned to the Projectile Development Establishment as superintendent, but in 1945 he went back to the headquarters of the Ministry as deputy director of the Directorate of Guided Projectiles. He became chief superintendent of the G.P. Establishment of Westcott in 1946. In 1947 he transferred to Admiralty service as the director of physical research in the Royal Naval Scientific Service.

Instruments for Radio-Isotope Research

THE Scientific Instrument Manufacturers' Association in collaboration with Harwell has produced a brochure summarising details of the equipment available from British sources for isotope techniques applicable in medical research and industry. Copies of the brochure are available on application to S.I.M.A., 17 Princes Gate, London, S.W.7.

Food Preservation with Antibiotics

SUBTILIN is the name of a new antibiotic substance which destroys food-decaying bacteria in much the same way that penicillin and streptomycin destroy disease-producing bacteria. Subtilin is produced by the submerged culture of *Bacillus subtilis*, a strain of bacteria found widely in nature and particularly in foods and food products.

Many foodstuffs, e.g. vegetables and meats, can be safely canned only if the heat treatment holds them at a temperature of 240° F. or more for periods of 30 to 60 minutes. If minute amounts of subtilin are added to the foodstuffs, satisfactory preservation by canning can be obtained with a treatment of from 5 to 20 minutes at 212° F. Normally the extra heating represented by the 212° F to 240° F. step is required to destroy spore-forming bacteria and one or two other spoilage organisms which are more stubbornly heat-resistant; the majority of the food-spoiling bacteria are destroyed by normal

pasteurisation temperatures, 180° F. to 212° F. Subtilin's anti-bacterial capacity appears to eliminate the higher range of heat treatment. Canned peas, corn, and asparagus have been tested and subtilin is also said to be effective in preserving beans, peeled potatoes, milk, and tomato juice. This work on subtilin is being carried out in the Western Regional Laboratory of the U.S. Department of Agriculture at Albany, California.

This adventurously new development in the antibiotic field is not yet within sight of commercial application. Indeed it is not yet settled whether subtilin has any deleterious effects upon human health or not. Subtilin at 100 parts per million has been added to rat diets, and no adverse effects have been observed over several months. A very large dose was given to a rabbit without harmful consequences. Nevertheless, the development phase of this American work is expected to take some years.

For the food canning industry subtilin might well be revolutionary. Lower temperature and lower time canning would mean better retention of food flavours and the more fragile nutrition factors. It also means economies in processing cost and equipment. Scientifically, subtilin might prove to be something of a milestone if it became the first antibiotic to develop an important use outside the medical field.

Freshwater Research in the Lake District

THE new headquarters of the British Freshwater Biological Association at Ferry House, Far Sawrey, on the Lancashire shore of Windermere, were opened on September 23 by Lady Albemarle.

End Government Atomic Monopoly, U.S. Chemist Urges

"THE U.S. Government should open up the field of atomic energy development to private industry, if real progress is to be made in working out peacetime uses of atomic power," said Professor Farrington Daniels, in his address to the National Chemical Exposition of the American Chemical Society. (Dr. Daniels directed the metallurgical laboratory at the the University of Chicago, where the atomic bomb was invented, and is now chairman of the board of governors of the Argonne National Laboratory).

Professor Daniels pointed out that the chemist can be justly proud of his contribution to the development of atomic energy, although many uninformed persons think that it is rather an achievement of the physicist. But he emphasised that there is still a tremendous challenge to chemistry in the problems that still lie ahead in the conversion of atomic energy to peacetime industrial uses.

"The government in five years has done nothing towards that end but plan," he said. "The five declassified nuclear reactors in this country are used only for the production of isotopes and for atomic research. None of them is being put to work on the problem of converting atomic energy into useful power. Meanwhile absolute government control of uranium, bars all private enterprise from the picture.

"Many of us believe that, if the opportunity were given to industry to take some of the chances involved, which the government is too cautious to take, we would get ahead much faster. Certainly we should be building pilot plants to solve problems such as the frequency of removal of atomic ash and of decontamination. Our present atomic piles work at far too low a temperature to be used for research on power sources."

Certainly world tensions require us to continue with the military atomic programme. Professor Daniels said, "But I insist that in the United States there are scientists, engineers and industrial companies not now engaged in the atomic energy programme who would, if given a chance, gladly and effectively develop pilot plants and full scale plants for the use of atomic power in the generation of industrial electricity." All we need is a change in policy to make more complete use of our natural and human resources and, if we fail to do this, we may be embarrassed sometime before long to find another country the first to demonstrate industrial electricity from atomic power."

Atomic power will come first in ship propulsion, Professor Daniels predicted, since the six feet of concrete required as a radiation shield around the atomic pile would be too heavy for smaller vehicles.

So far, Professor Daniels said, "no one that I know of has come up with a really practical idea for the direct conversion of atomic energy into electricity. He noted, however, that gas turbines operating at extremely high temperatures could theoretically be so efficient that direct conversion into electricity might become of lesser importance.

The problems challenging the chemist in the development of nuclear energy are many, Professor Daniels pointed out. It is of great importance now, for instance, to find ways of recovering uranium from low-grade ores including phosphates, shales and some granites. Some other chemical possibilities are the discovery of better methods of separating atomic ashes from the fuel of the pile and of using the large amounts of isotopes now accumulating in storage as wastes.

Obituary

GENERAL SMUTS, who died on September 11, had close connexions with the world of science. He was himself a keen botanist. In 1931 he was president of the British Association for the Advancement of Science, when the Society held its centenary meeting in London. His book, *Holism and Evolution*, which was widely discussed among the scientific world, was published in 1926.

Night Sky in November

The Moon.—New moon occurs on November 9d 23h 25m, U.T., and full moon on November 24d 15h 14m. The following conjunctions with the moon take place:

November

6d 19h	Saturn in conjunction with the moon	Saturn	2° N.
13d 04h	Mars ,,	Mars	4° N.
16d 23h	Jupiter ,,	Jupiter	1° N.

The Planets.—Mercury is in superior conjunction on November 1 and is too close to the sun during the month for favourable observation. Venus, in superior conjunction on November 13, is too close to the sun during most of the month for observation. Towards the end of November the planet sets about half an hour after the sun and can be seen for a short period in the western sky. Mars is an evening star and sets more than two hours after the sun throughout the month but lies too low for favourable observation. Notice that the planet is very close to λ Sagittarii—just slightly north of the star—on November 12 and 13, and on November 20 and 21 is a little north of σ Sagittarii. Jupiter sets at 0h 10m, 23h 21m, and 22h 30m, on November 1, 15 and 30, respectively. Throughout the month the planet is close to ι Aquarii—slightly north of the star—and moves a little farther north of it as the month progresses. Saturn, a morning star, rises at 3h, 2h 15m, and 1h 25m at the beginning, middle and end of the month, respectively, and can be seen about midway between β and η Virginis. The north side of the ring is now visible.

The constellation of Perseus, visible at this time, contains many interesting objects amongst which may be noticed two clusters at the north of the constellation, visible to the naked eye and presenting a wonderful sight with slight optical aid. The larger of the two contains many stars ranging from magnitude 6 to about 14. The other cluster is not such a striking object and towards its centre the stars appear condensed. A pair of binoculars directed to the region around α Persei shows a very fine arrangement of stars, which forms a beautiful object. While on the subject of Perseus, look at Algol, one of the best known variable stars, its period between maxima or minima being 2·87 days, approximately. As no useful purpose is served by giving its times of minimum during daylight, the following five times may be of interest; November 1d 19h 30m; November 16d 3h 30m; November 19d 0h 24m; November 21d 21h 12m; November 24d 18h. The variation in brightness is from 2·2 to 3·5 magnitudes.

Television Progress: 345,000 Licences

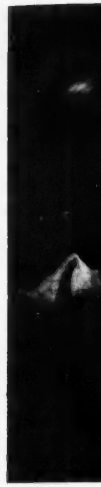
ACCORDING to the annual report of the B.B.C., 11,998,000 wireless licences were issued during the year ending March 1950, and the number of television licences was 345,000, more than two-and-a-half times as many as in the previous year.

Prospecting for Radioactive Minerals

WE have received a number of letters asking which firms produce equipment that can be used for finding radioactive minerals. The following is a list of firms making equipment for this purpose: Labgear Ltd., Willow Lane, Cambridge; Cinema Television Ltd., Worsley Bridge Road, Lower Sydenham, S.E.26; Panax Ltd., 347 London Road, Mitcham, Surrey; E. K. Cole Ltd., 5 Vigo Street, London, W.1.

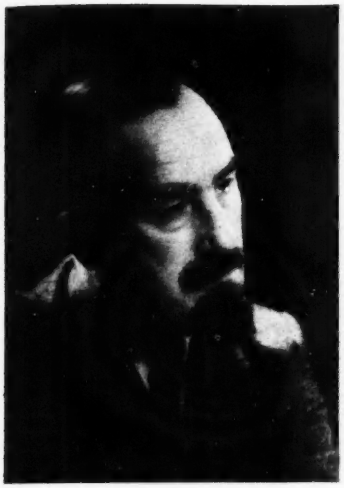
How Poliomyelitis Paralyses

Dr. F. K. Sanders, of Exeter College, Oxford, read a paper to the Physiology Section of the British Association, in which he described experiments intended to throw



Dr. Sher
Science M

light on the
tile paralysis
only anima
virus, howe
keys, which
there is a
which altho
fantile para
mice in a re
virus of infa
Work on t
mouse virus
that would
in the case
Dr. San
governing t
central ner
situation as
jected into
there is a
probably s
junction, a
injection of
therefore, s
inoculated.
virus is ab
muscle to a
this 'barrie
connection
paralysis h
in children
barrier has
travels to th
the actual
the muscle.
fiftieth-of-a
passage it
of this proc
microscope
November
tration to t
against Pol
origin of t
travelling,
end of the c
cells are de
ness, with i
same time



Dr. Sherwood Taylor, director of the Science Museum in succession to the late Dr. Herman Shaw.

Dr. John Ramsbottom, who retires from the post of Keeper of Botany in the Natural History Museum.

Dr. George Taylor, who succeeds Dr. Ramsbottom. He has been at the Natural History Museum since 1928.

light on the behaviour of the virus of infantile paralysis when it enters the body. The only animals regularly susceptible to the virus, however, are chimpanzees and monkeys, which are extremely expensive, but there is a natural virus disease of mice, which although not a close relative of infantile paralysis, nevertheless behaves in mice in a remarkably similar manner to the virus of infantile paralysis in the monkey. Work on the general behaviour of this mouse virus might therefore have results that would suggest lines of investigation in the case of infantile paralysis.

Dr. Sanders examined the factors governing the transmission of virus to the central nervous system in such a simple situation as that in which the virus is injected into a muscle. It was found that there is a 'barrier' to virus invasion, probably situated at the nerve-muscle junction, and the events following the injection of the virus into a muscle depend, therefore, strictly on the quantity of virus inoculated. In very young animals the virus is able to multiply locally in the muscle to an extent sufficient to overcome this 'barrier'. (This seems to have some connection with the fact that infantile paralysis has more serious consequences in children than in adults.) Once the barrier has been penetrated the virus travels to the central nervous system along the actual fibres of the nerve supplying the muscle, with a speed of about one-fiftieth-of-an-inch per hour, and during its passage it does not multiply. (A picture of this process, taken through the electron microscope, was published in DISCOVERY, November 1948, vol. 9, p. 347, as an illustration to the article entitled "The Fight against Polio".) On reaching the cells of origin of the nerve fibre in which it is travelling, multiplication starts. At the end of the cycle of multiplication the nerve cells are destroyed with explosive suddenness, with inevitable paralysis, and at the same time a large quantity of new virus is released from the destroyed cells. At the beginning of its multiplication the virus seems to lose its identity completely and to be built into the cell structure. But later on, some fundamental dislocation of the life of the cell occurs, accompanied by the dissolution of its structure and the appearance of more virus. The nature of this process is a problem for future investigation.

Forcing Tulips with Artificial Light

THE forcing of tulips by artificial light is already under way in Holland, and some details of the technique are given in a recent number of *Philips Technical Review* (Vol. 10, No. 9). A shed was insulated with fibre board which also shut out all light, and was then warmed to a constant temperature of 22°C. by a stove. 75-watt incandescent electric lamps were installed to give an illumination of 90-watt per square metre of illuminated area. The bulbs were grown in boxes about 2½ ft. below the electric lights.

The first batch of bulbs to be forced, of the 'Krelage's Triumph' variety, showed exceptional development right from the start: the boxes of bulbs were placed in the shed on December 18 and the blooms began to appear 17 days later. For comparison a number of bulbs from the same lot were set in a greenhouse for forcing in the conventional manner. Not only was the quality of the tulips in the lighted shed definitely better, but the proportion of stragglers was very much smaller, being only 4% as against a normal 10% to 15%. A similar result was obtained when the experiment was repeated with a later-flowering variety of tulip.

The electric lamps were kept burning 9 hours a day. Continuous illumination was less satisfactory, producing too much leaf.

Running expenses, it is claimed, are actually reduced.

Films and Anthropology

IN a lecture to the Scientific Film Association recently Dr. E. R. Leach of the London School of Economics dealt with the intelligent use of the film in the study of anthropology. Dr. Leach said there were few films of real use to the anthropologist, and the anthropologist himself seldom made a film which was suitable for the student. The essential qualities demanded in the anthropological film were authenticity, intelligent use of the camera, and analytical detail rather than a complete superficial record. Dr. Leach said there was a real place for the film in the study of anthropology if it conformed to the requirements mentioned. *Bugufi*, a film which dealt in detail with the whole process involved in the manufacture of a hoe by African natives from the discovery of the ore to the finished article, was a good example of the well-made film and eminently suitable for the elementary study of anthropology. Striking evidence of lack of vision on the part of the film producer was provided by the recent film made for the Colonial Office *The Plainsmen of Barotseland*, a film with great possibilities but which failed entirely to attain its objective by reason of the unrelated sequence, undue emphasis on unimportant details, and the omission of much relating to the life and habits of the people concerned. *Tjurunga* a film made by the Australian anthropologist C. P. Mountford whilst excellent in many respects lost its value for serious anthropological study by reason of the fact that it had been designed for popular appeal; the opening sequence of the film stressing the immense self-sacrifice of the anthropologist in the interests of his subject was a typical example of this fault. *Bharata Natyam* a film describing the Indian native dance had real value for the student in that it gave an authentic and detailed picture of the subject. The last three can be borrowed free from the Central Film Library.

The Bookshelf

Astronomy of Stellar Energy and Decay. By Martin Johnson. (London, Faber & Faber, 1950, pp. 216, 4 plates, 16*s.*).

THE subject of stellar evolution is one in which the strongest opinions seem usually to be bred from the sketchiest of information; so I began to warm to this book as soon as I read in the foreword by Professor F. J. M. Stratton the words: "His method of approach to the subject has saved Dr. Johnson from a fault common among writers of popular books on science, an undue dogmatism in matters that are still open to dispute." I warmed still more when I found Dr. Johnson saying: "It is advisable to stress this dependence of astrophysics upon a laboratory science now very widespread, since the most universally read books on stars have been the masterpieces of popularisation by the late Sir Arthur Eddington and Sir James Jeans. Both were workers with brain, library and study table, rather than with laboratory apparatus; they were also philosophers who presented among their popular astrophysics important but highly individual opinions about the ultimate significance of the universe—concerning which physics itself, terrestrial or stellar, must be silent. There is accordingly a widespread impression, among physicists as well as among general readers, that astrophysics is a spinning of *a priori* speculation." This is the first of a series of nails which Dr. Johnson hits squarely on the head. It cannot be too strongly emphasised that most astronomers are less worried by epistemology than by what is going to go wrong with the telescope next.

This book is good solid stuff: it is arranged in two parts. First, there is a general review of the known facts of stellar behaviour. Secondly, there are a series of fairly short chapters amplifying and discussing the topics broached in the first part. I confess that at first I did not entirely like this arrangement since it makes cursive reading a little difficult. But on reflection I begin to like it much more since it has the advantage of enabling one to turn up a topic very easily. Dr. Johnson has a very good knowledge of recent astrophysical literature and by using this book as a work of reference one will be able very readily indeed to get a true perspective of a large number of astrophysical topics.

Before I mention what seems to me the chief service which Dr. Johnson has rendered in producing this book, let me note two detailed points. First, a criticism: this book would have been easier to read but for a stylistic trick of Dr. Johnson's, a habit of omitting articles and even nouns from his sentences. Secondly, a well-deserved bouquet; the book is beautifully got up, a particular high point being the superb reproduction of a superb photograph of the Crab nebula taken by Baade.

But Dr. Johnson's most signal service is not a question of detail but of principle. There is a grave lack of up-to-date working text books for the astronomical student in Britain. There are plenty of books of an elementary kind: there are plenty of books on mathematical astronomy, and plenty which treat astrophysics as if it were no more than an exercise ground for the mathematician. What is needed for the student is something a little more advanced, quite modern, combining the observational and the theoretical sides, which will enable the student to get a firm grasp of essentials before he has to pick his way through the vast and somewhat unco-ordinated literature of modern astrophysics. Dr. Johnson's book is to be welcomed especially as partly filling this gap, and should be welcomed even more warmly because it shows unmistakable signs of being the crystallisation of a series of lectures which have undergone the stern refining process of delivery to critical student audiences.

D. S. EVANS.

Quakers in Science and Industry. By Arthur Raistrick, M.Sc., Ph.D. (London, The Bannisdale Press, 1950, pp. 361 with 17 plates and 10 charts, 21*s.*).

IN this well-written study Dr. Raistrick gives an account of the Quaker contribution to science, industry, medicine, trade and banking during the seventeenth and eighteenth centuries; that is, from the beginnings of modern science to the opening phases of the Industrial Revolution.

When George Fox in the 1650's founded the group "in scorn called Quakers" and named by themselves "The Society of Friends", the movement was largely revivalist in outlook and craftsman-artisan in composition. After much severe, almost incredibly severe, persecution in the seventeenth century, when the Quakers numbered forty thousand in a total population of about four and a half millions and were considered a menace to Church and State, the Society moved into quieter and more secure waters early in the eighteenth century; and its members soon began to play an outstanding part in British life. At the end of the eighteenth century, the members of the Society can be correctly described as predominantly middle-class traders, but their spiritual vision remained undimmed. Their most outstanding achievement may well have been their individual loyalty to their beliefs, and especially the practice of those beliefs in their daily lives. Their ideals, love of truth and scrupulous fairness, their 'inner light' inspired all their actions.

Among the many names famous in science to be found here are those of Peter Collinson, who, in a remarkably full and busy life, did much to bring the electrical work of Franklin to the notice of the Royal Society; of William Curtis, founder of the still current *Botanical Magazine* (it was founded in 1787); of John Dalton, founder of the chemical Atomic Theory; of the Quaker doctors, John Fothergill and Lettsom; and of many others. The work of all these is described in non-technical language; and the author presents their achievements as arising from their Quaker attitude to the various problems, scientific and social, that confronted them.

Much hard work with study of many original sources and documents has gone to the making of this most readable book. It is strongly recommended to all with an interest in history and in science.

D. MCKIE.

Lilies of the World. By Hubert B. Drysdale Woodcock, F.L.S., & William Thomas Stearn, F.L.S. (London, Country Life Limited, New York, Charles Scribner's Sons, 1950, pp. 431, 132 half-tone photographs and 136 line drawings, 35*s.*).

APART from the Madonna Lily (*L. candidum*) and the Tiger Lily, the lilies are somewhat neglected by gardeners. The decline in the cultivation of lilies can be traced back to the introduction of the Japanese *L. auratum*, a very beautiful flower but one so prone to virus infection that the idea gained currency that lilies are altogether too difficult to grow. Actually these flowers have been climbing back into favour since the beginning of this century, and today an average nurseryman's catalogue shows about 20 species that can be grown with reasonable prospect of success. To make the best of them, however, one needs a reasonable amount of knowledge about their ecology and the soils that suit them, and it is an advantage to know all the scientific aids to cultivation that are available. Everything one can possibly want to know is in this book; the history of lilies, cultivation, propagation, hybridisation, pests and diseases (and their control), are all covered very fully. The many different kinds, not only of *Lilium* but also *Cardiocrinum, Korolkowia, Nomocharis* and *Notholirion*, are systematically described; as a consequence of its systematic arrangement, the book is ideal for reference purposes, and sets a pattern which other authors in these days when science is entering more and more into horticultural practice could follow with great advantage to the readers of such books. The book contains excellent half-tone illustrations; one might wish for colour plates, but these are by no means indispensable, and colour plates would have made the volume prohibitively expensive.

A Manual of Organic Chemistry for Advanced Students, Vol. I. By G. Malcolm Dyson. (London, Longmans Green, 1950, pp. 684, 63*s.*).

THE Honours student of chemistry has lacked a suitable text-book of organic chemistry for many years. 'Schmidt' as a single-volume handbook is useful but does not go far enough. The old three-volume 'Cohen' was not even really useful. The first volume of Dr. Dyson's new book does, however, hit the mark.

The text is factual and descriptive and obviously the work of a manufacturing organic chemist. The industrial approach puts into perspective the relative importance of various compounds and reactions

for their preparation. To some extent there are gaps and discrepancies where the author has no contact with large-scale practice but it is in fact more remarkable that the gaps should be so few. This first volume is concerned with compounds of carbon, hydrogen, oxygen and the halogens. It gives scope for descriptions of the petrochemical route for large tonnages of organic materials as well as alternative methods from acetylene through acetaldehyde or Reppe syntheses, fermentation and Fischer-Tropsch processes. All this is done while preserving the essential text-book method of classifying and describing groups of compounds from one homologue to the next.

This would be expected from an author who is prepared to put forward a new system of nomenclature, which is an apparently flawless method of overcoming difficulties in the Geneve system. Until its adoption he is prepared to show how the Geneve system can be worked and information extracted. The introduction to the book is a model of instruction on the way to carry out a literature search.

This book can be recommended not only to the student but to all workers in any field having organic chemical connexions. It is concise, informative and refreshingly free from electronic extravagances.

F. E. W.

Fungi—Friends and Foes. By A. F. Parker-Rhodes. (Paul Elek, London, 1950, pp. 140, 12*s*. 6*d*.).

THE fungi may well include some 75,000 species, many of which have been thoroughly studied because of their economic importance. An author who sets out to introduce this enormous and diverse group of organisms to the non-technical reader has a formidable task in selecting his matter from a great volume of detail, and, as fungi tend to repel rather than to awake interest on first acquaintance, he has the special duty of presenting his selected material in a form complete enough to arouse his readers' interest and to stimulate their thoughts.

The photographs which illustrate the book are both attractive and satisfying, but the line drawings are often so roughly prepared that they may well mislead persons who have never observed fungi with a microscope. Perusal of the text leaves the uncomfortable feeling that the author has not always used his facts to the best advantage in developing stimulating lines of thought.

It is impossible to avoid comparing the book with others which have been written for the non-technical reader who wishes to know something of the fungi. E. C. Large, in his *Advance of the Fungi* (Jonathan Cape, 1940, reprinted 1946), describes, in most dramatic style, the fungi as the causes of plant diseases, while a more formal general treatment, in small compass, is to be found in the introduction to J. Ramsbottom's *Handbook of the Larger British Fungi* (British Museum, Natural History, 1946). Anyone who can obtain a copy of Ramsbottom's *Fungi, an introduction to mycology* (Benn's Sixpenny Library, 1929), will find there an outstanding example of what can be done, in limited space, to expound mycology, simply, worthily and convincingly. It is much to be hoped that a revised version of this excellent little book of Ramsbottom's may some day be made available for the instruction and delight of the beginner in mycology. B. BARNES.

Wild Animals in Britain. By Oliver G. Pike. (Macmillan, London, 1950, pp. 233, illustrated, 18*s*.).

THIS new addition to the publisher's series, which already contains useful volumes of Trees, Flowers, Birds and Dogs, has the same general features as its fellow volumes. The mammals, reptiles and amphibians found wild in Britain are dealt with in straightforward fashion, each species being described in considerable detail, with much of interest and entertainment in the way of anecdotes from the observations of the author and other field naturalists. There are one or two rather surprising statements, such as that "in a few years, new soil to the depth of several inches is added to the meadow, and this is all the work of the despised earthworm"; and the details of the mating of badgers appear to take no account of the classic work of Neal in his monograph published last year. Somerset, again, is surprisingly not mentioned as a haunt of the red deer, so strongly established on Exmoor and the Quantocks; and there is no mention of the Japanese deer, surely wild in many places, nor of the glis-glis, now widely accepted as a well established alien.

On the whole, however, this is a useful book, written with Mr. Pike's accustomed fluency, well illustrated, with some charming colour plates as well as many photographs, and good to look at. With the present enormous increase of interest in Natural History, there are far too many second-class books on such subjects as this, but the present volume is certainly worthy of a place in the modern naturalist's permanent library. P. B. C.

Interplanetary Flight. By A. C. Clarke. (London, Temple Press, 1950, pp. 164, 15 plates, 8*s*. 6*d*.).

INTERPLANETARY travel is one of those subjects which, in the past, has become involved with all kinds of bogus notions and ideas; materials impermeable to gravity, energy generators of minute size and fantastic power, gases lighter than hydrogen, and so forth. Nevertheless, it has always been a serious subject, in the sense that it has always been possible to evaluate the conditions which would need to be satisfied in order to project a body from the earth to another planet, or into an orbit circling the earth. In fact many people, both fiction writers and serious scientists, have made such investigations in the past and have come to quite sound and unimpeachable conclusions concerning the energy and velocity requirements in any given case.

But now, interplanetary travel seems to be moving out of the realm of fiction and speculation into that of serious investigation. The velocities of guided missiles, while not yet sufficient to remove a body from the capture region of the earth, are beginning to get near the necessary values. If we extrapolate from the knowledge of rocket propulsion of a quarter of a century ago to that of the present day and then on into the future, the subject matter of Mr. Clarke's book passes from the category of wild speculation into something approaching a reasoned prediction. One only needs to look at Mr. Clarke's Plates II and III—on the left the first liquid fuel rocket of 1926 weighing a few pounds; on the right a thing the size of a house about to be launched into space—to be forced to begin to think very seriously. Subjects such as the protection of space ships against meteor impact and the probability of its occurrence are now topics for sober scientific assessment. Unless the human race annihilates itself with its own fatal ingenuity, this then is how the future may look, as soon as some nation decides that it is worth while to spend the fantastic sums which will be necessary for making interplanetary journeys or for establishing space stations which are, so to speak, artificial satellites of the earth.

The first part of the book deals with the general mechanics of the problem—orbits of minimum energy, times of flight, starting velocities and so forth. Then Mr. Clarke goes on to such topics as the possibilities of atomic energy, the establishment of space stations and the problems of communication in space. As far as I am able to judge, Mr. Clarke comes down pretty competently to numerical calculations (these are in the appendices) and has a sound scientific approach to these problems. That is not to say that I feel able to swallow all the details, but if, as I take it to be, this book is intended to be a general survey of the field, then as to the majority, I find it digestible enough.

For example, I feel that Mr. Clarke is probably optimistic about atomic energy possibilities: I would like to see a detailed discussion of the orbital stability of space stations: I doubt whether, in detail, these artificial satellites will be realised in the form in which they are described: I find his illustration of constructional work on the moon a little too much like Superman for my taste.

But apart from points of this kind, the work is serious, well set out, and lucidly expressed. It may give one a slightly odd feeling—it certainly does me—to be forced to the conclusion that getting out into space is not so far outside the realm of possibility. If you don't believe it, read this book and judge for yourself.

D. S. EVANS.

Guide to British Insects. By B. D. Moreton. (London, Macmillan, 1950, pp. 196, illustrations, 8*s*. 6*d*.).

THE aim of this book is primarily to help farmers, gardeners, agricultural students and others, to classify, without specialised scientific knowledge, such insects as they are likely to encounter in the course of their work. Especially good is the general chapter on structure and life-history, which could well serve as a general introduction to entomology. The keys for identification are also good and easy to use, and

the descriptions of the insect orders, family by family, enable reasonably exact identification to be carried out, at least where important economic species are concerned. Perhaps too much reliance is placed on the magnifying glass as a means of identification . . . how many of those for whom the book is intended will really carry this about with them?

Another criticism concerns the illustrations. The drawings, excellent in themselves, are made less valuable by the bewildering variation in scale, which could itself be clarified by the normal use of straight lines indicating natural size and wing span. The photographs are much less satisfactory, especially those of beetles, since they give little idea of anything except the outline of the species concerned. Even allowing for its deliberate bias towards insects of economic importance, and for the fact that it is for reference rather than a field hand-book, it will prove useful for the would-be naturalist and the general biology student; in this connection, the bibliography and glossary are especially welcome. P. B. C.

Animal Facts and Fallacies. By Osmond P. Breland. (London, Faber & Faber, 1950, pp. 245, 10*s.* 6*d.*)

THIS book is a stimulating work of 'popular science'. The author has discarded the inhibitions of orthodoxy in his presentation, and his script is a long series of crisp articles with such titles as "Can a Swordfish Sink a Boat?" or "Fish That Climb Trees." A first glance through the book may give an impression of an animal cavalcade of "believe-it-or-not" tit-bits, but this is clearly a risk that the author has taken for the sake of securing reader-interest on the widest possible level. But as soon as reading takes the place of scanning, the solidity of the book is apparent. Each article is soberly but clearly written. It is possible that other branches of scientific knowledge might be usefully presented to the public in this manner. The usual popular science book with reliable background is written with the assumption that the majority of potential readers will in any case have the initial desire to tackle it. Professor Breland has gone farther; he has tried to tempt non-potential readers into liking the look of his book. He has accepted the hard fact that other authors must face, that people have a limited time for reading and many hundreds of books of diverse kinds compete for their armchair or bedside hours.

This book may well inspire quite a number of children to develop a serious interest in biological science.

LETTERS TO THE EDITOR

The Horsepower of a Whale

Sir,

I was very interested in some figures given in an article "The Dolphin and the Whale" (DISCOVERY, January 1950), and in particular was surprised at the smallness of the figure for the whale's available horsepower.

Some years ago, when on the south coast of Natal, I was fortunate enough to see a blue whale, quite close in, doing what I believe is called 'broaching'—i.e. leaping nearly vertically out of the water and crashing back again in an attempt to knock off barnacles, etc., on its skin.

This whale broached twice, with a counted interval of about 15 seconds between jumps, and each time it was momentarily poised in the air, nearly vertical and with its flukes just showing above the water—a wonderful sight.

Now, assuming its length to be 60 ft. and its centre of gravity about 20 ft. from the head end, it would seem that its speed at the moment of leaving the water would have to be about 50 ft. per second, or roughly 30 knots—a much higher figure than Professor Hill's maximum of 20 knots.

Again, it is admittedly difficult to say how much forward speed it gained in the fall, but assuming it was 20 ft. per second, which I think is a high estimate, it is possible to find the power necessary to make a second jump 15 seconds later.

This comes to about 550 h.p.—again a much higher figure than Professor Hill's estimate of 160 h.p.

Has anyone similar observations to mine from which similar calculations could be made?

Yours, etc.,

Durban North, Natal, South Africa. J. B. COLAM

Professor A. V. Hill comments as follows on Mr. Colam's letter:

Mr. Colam's interesting observation provides no difficulty of interpretation if we take the analogy of human athletics. The maximum speed which a human runner can keep up for a long time (i.e. in a 'steady state' of oxygen consumption) is about 5½ yards/sec.: the maximum speed developed by a sprinter (after about 40 yards) is about 12 yards/sec., but he is then using energy at a rate far exceeding that provided by contemporary oxygen consumption, and his speed quickly falls off. At top speed his 'accumulators' are being rapidly run down. The absolute maximum speed, therefore, is rather more than twice the maximum maintained speed. The same principle (for a physiological principle is involved, not merely an empirical fact) should apply to whales, and a maximum maintained speed of 15 knots would imply an absolute maximum of rather more than 30 knots. My 20 knots was not an estimate of the absolute maximum speed, but of the speed that might be kept up for a few minutes, corresponding rather to a half-mile by a human runner.

A man cannot maintain more than a steady 0·35 h.p.—but for a few seconds (as in running up stairs at top speed) he can develop at least five times as much: which would allow the whales' 160 h.p., for the short time required, to become 800.

It seems still not to be realised by non-physiologists that animal muscles develop power by chemical processes analogous to the discharge of an accumulator. This discharge can take place at a very high rate, much higher than the maximum rate of recharge at the expense of energy derived from combustion. The absolute maximum power output is determined by the maximum rate of discharge of the accumulators, but the maximum maintained output cannot be greater than that which corresponds to the maximum rate of combustion, which is determined by the maximum rate of oxygen supply through lungs and circulation. We should be very poor creatures were we not able to exert ourselves at a rate higher than we can keep up for a long time.

"Shell" Films on Pests

Sir,

Would you give us space to reply to the criticism in your September 1950 issue that the series of colour films on pests made by the Shell Film Unit contained no information dealing with the control of the various pests and diseases.

The inclusion of a sequence, or sequences, dealing with methods of control was considered at the script stage in 1947, but was rejected for the following reasons:

1. The machines and the preparations used for the control of pests and diseases are continually changing as the result of research, whereas we hope that the present films will last at least until new techniques in photomicrography render them obsolete.
2. To show controls in each of the ten films would be mostly repetitive.
3. For farmer and fruit-grower audiences the films would be used by a lecturer who would discuss control methods.

Yours, etc.,

A. WOLCOUGH
The Shell Petroleum Co. Ltd.

Fresnel and the Honey Drop

Sir,

In the article (September 1950 issue, p. 276) reporting Sir Lawrence Bragg's speech at the opening of the new Dunlop Research Centre, a small error may be detected, but this in no way invalidates the point made. Fresnel obtained approximately monochromatic light by means of red glass obtained from a church window, but the honey drop was a substitute for a heliostat.

Yours, etc.,

R. PARDOE

Our correspondent seems to be right. The latest biography of Fresnel (by G. A. Boutry, published last year by John Murray) has this to say about the experiment: "The sun was Fresnel's only available source; he owned no heliostat. But his mother kept bees: a drop of honey filling a small hole provided him with a short focus lens which gave almost a fixed image of the sun."

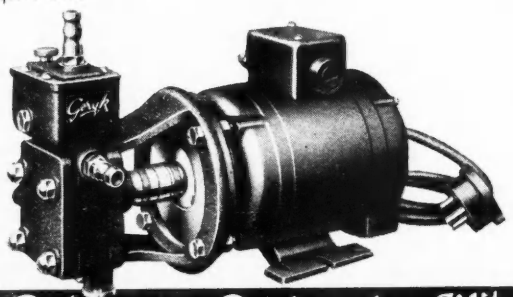
Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. *Editorial Offices: 244 High Holborn, W.C.1.*

Pulsometer

Geryk VACUUM or PRESSURE PUMPS

RESEARCH WORKERS Save your high vacuum pumps for high vacuum work. Use this unit for the odd jobs.

Characteristics: 1. Portable. 2. Stands on the bench. 3. ⅙ H.P. motor with trailing lead. 4. Easy to clean and service. 5. Swept volume : 1 cu.ft/min. 6. Vacuum ·01 M/M. 7. Pressure 10 lb/per square inch.



Pulsometer Engineering C°. L^td^.,
Nine Elms Ironworks, Reading.

FARADAY HOUSE ELECTRICAL ENGINEERING
66, Southampton Row, W.C.1.

A 4-year full-time course, which includes practical training with mechanical and electrical engineering firms, for the Faraday House Diploma which is accepted for Graduate Membership of the I.E.E.

For particulars apply Dept. E.

DISCOVERY

Any difficulties met with in obtaining DISCOVERY from newsagents or booksellers can be overcome by writing to the

CIRCULATION MANAGER,
The Empire Press, Cowgate, Norwich

Are you interested in farming?

FARMING

is the sister magazine to *DISCOVERY*. It brings to the practical farmer news of what is going on at the Research Stations.

PRICE AND ORDERS AS FOR *DISCOVERY*

Visual Colorimetry

The description in simple and mathematically recordable terms of *what a colour looks like.*

The
LOVIBOND TINTOMETER

now available from stock, has perfectly fulfilled this function for 70 years, and its use and popularity is still increasing.

Write for new booklet
"Colour, and the Visual Measurement of Colour" by A. J. Fawcett. Price 1s. 9d. *post free*
from
THE TINTOMETER LIMITED
SALISBURY ENGLAND

Rectophot
RAPID REPRODUCER

PERFECT PHOTO COPIES
IN YOUR OWN OFFICE
WITHIN A FEW MINUTES

•

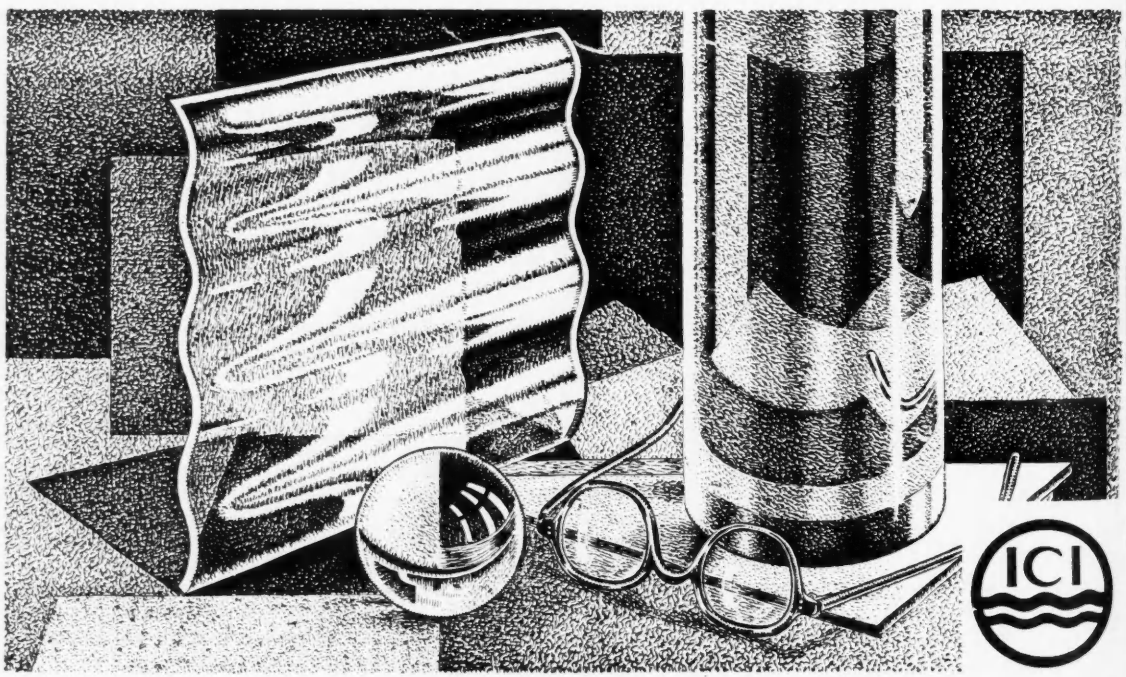
NO DARK ROOM
NO LENS
NO MISTAKES

•

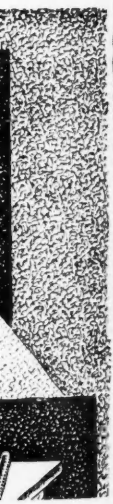
PARTICULARS FROM
A. WEST & PARTNERS LTD.
36, BROADWAY, LONDON, S.W.1
TEL.: WHITEHALL 5677

'Perspex'

'Perspex' acrylic resin is one of the most versatile and attractive of the new synthetic materials which the British chemical industry has yet produced. Since I.C.I. chemists discovered it in 1932, this crystal-clear plastic has found hundreds of uses as varied as the transparent parts of aircraft, electric light fittings, chemical plant, and corrugated sheets for roof lighting. 'Perspex' is made from acetone, of which one method of manufacture is based on molasses, a by-product of sugar manufacture. The first step in making it is to produce a water-white liquid called methyl methacrylate. The next is to polymerise this liquid—that is, to cause its molecules to join in long chains. The result is polymethyl-methacrylate which is sold under the proprietary name 'Perspex.' Although only half the weight of glass, 'Perspex' is extremely tough, and its development was a timely achievement of the British chemical industry. In 1939 it was adopted for the transparent parts of all British fighting aircraft and today new uses are constantly being found for it.



nacrylate.
—that is,
ng chains.
e which is
Perspex.'
'Perspex'
ent was a
chemical
for the
g aircraft
ing found



ICI